DIGITAL ENCIPHERING OF ENGLISH INTO BRAILLE

NEMETH ABRAHAM

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DIGITAL ENCIPHERING OF ENGLISH INTO BRAILLE

by

Abraham Nemeth

A DISSERTATION

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APPROVED BY:

Charles T. Briggs
Adviser Date

Leon Brown
Date

Paul Weiss 8-19-64
Date

....
Date

FOREWORD

The problem of making braille reading matter available in quantity and with speed is one which has concerned the writer for a long time. The means of braille production has not kept pace with general technological developments, and the writer, because he depends on braille, has been acutely aware of this unnecessary limitation on the direct access to the written word.

The writer was prompted to undertake this investigation in the hope of making a contribution to the above mentioned objective because he possesses a knowledge of computer programming as well as of the rules of braille.

Acknowledgement is made to the Office of Vocational Rehabilitation of the Department of Health, Education, and Welfare under whose grant this project (No. 433) was made possible.

Abraham Nemeth
Detroit, Michigan
1964

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DIGITAL ENCIPHERING OF ENGLISH INTO BRAILLE.

Project No. 433

1. BACKGROUND AND STATEMENT OF THE PROBLEM.

1.1 Nature of the Braille System

The system of raised dots by which reading and writing are made possible through the sense of touch, and which is primarily intended for use by blind people, is known as the Braille System after its inventor, Louis Braille (1809-1851).

Although the system was slow to be adopted, extensive experience as well as controlled experiments have proved beyond any reasonable doubt that a system which appeals to the sense of touch and is based on the principle of raised dots is superior to one which is based on the principle of raised lines, both in the ease of symbol discrimination by touch, and in the capacity for sustained reading. Accordingly, the Braille System has gained worldwide acceptance and, in recent years, under the auspices of UNESCO has been standardized to meet the needs of every major language and dialect in the world.

The superiority of a system of raised dots over one of raised lines is explained by the phenomenon of tactual adaptation. After a relatively short time of reading raised lines, the threshold of sensation and of discrimination becomes higher and interferes with the efficiency of the reading process. This phenomenon seems to be absent in the case of raised dot symbols.

The symbols used in the Braille System are quite arbitrary; the forms of the printed letters and other signs are not imitated.

1.1.1 The Dot.

In the Braille System, each dot is in the shape of a hemisphere. For optimum reading efficiency, experiment has shown that dots should be of uniform height and raised 0.018 of an inch above the surface of the paper. For permanent records, braille paper should be 0.006 to 0.008 of an inch in thickness.

1.1.2 The Cell

In the Braille System, the raised dots are grouped into units called cells. When all the dots in one cell are present, they constitute a rectangular arrangement of six dots. The dots are arranged in two columns, and there are three dots in each column. Numbers, from 1 to 6, are assigned in a standard manner to the dot positions within each cell. The standard dot numbering is shown below:

```
1 •• 4
2 •• 5
3 •• 6
```

For optimum reading efficiency, the distance between two adjacent dots within the same cell, either in the vertical or the horizontal direction, should be 0.090 of an inch, the measurement being made from dot center to dot center.

A braille symbol may be described completely by specifying the dot positions, by number, which must be used in its formation. It is standard practice to specify these numbers in ascending order. Ex.:

The braille symbol

is completely specified as 1-3-6. The braille symbol consisting of no dots may be specified as 0.

There are 64 distinct dot combinations which can be formed within a single cell. One of these combinations is the one in which all dots are absent. The literature dealing with the Braille System ordinarily refers to this symbol as the space, but refers also to 63 possible dot combinations; and in so doing, the space is excluded from the set of possible dot combinations.

As a matter of standard procedure, the 63 nonempty dot combinations are listed in the order shown below. According to this arrangement, the braille symbols are grouped into seven lines. In this investigation, the empty combination has been added as the last braille symbol on line 7.

TABLE 1
THE 64 BRAILLE SYMBOLS

LINE 1

LINE 2

LINE 3

LINE 4

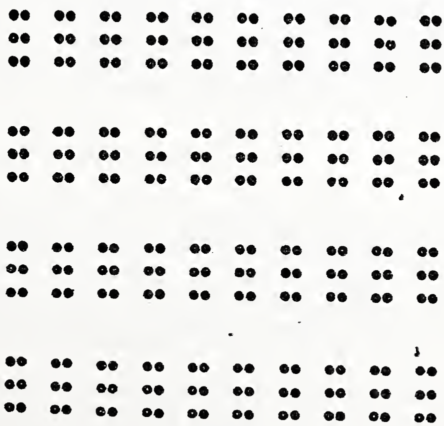
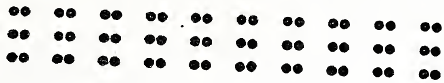


TABLE 1 (continued)

LINE 5 

LINE 6 

LINE 7 

The ten braille symbols on line 1 contain neither dot 3 nor dot 6. The symbols of line 2 are formed by the addition of dot 3 to the corresponding symbols of line 1. The symbols of line 3 are obtained by the addition of dots 3 and 6 to the corresponding symbols of line 1. Line 4 is obtained by the addition of dot 6 to the corresponding symbols of line 1. The symbols of line 5 have the same configurations as the corresponding symbols of line 1, but, in the case of line 5, the lower two-thirds of the cell is occupied by the braille dots rather than the upper two-thirds of the cell, as in line 1. Thus, the symbols of line 5 contain neither dot 1 nor dot 4. The symbols of line 6 are those, not listed in any of the foregoing lines, in which dot 3 appears. The symbols of line 7 are all the possible combinations, including the empty combination, which can be formed by the use of dots 4, 5, and 6 only.

Braille symbols which contain neither dot 1 nor dot 4 are called lower signs; braille symbols which contain either dot 1 or dot 4 are called upper signs. There are 16 lower signs and 48 upper signs. The reader is referred to ENGLISH BRAILLE — AMERICAN EDITION, 1959, American Printing House for the Blind, Louisville, Kentucky, 1959, and in particular to the introductory section entitled Definition of Braille. This reference work is described in section 1.3.

1.1.3 The Braille Line and Braille Page

In the Braille system, as in ordinary print, symbols are consecutive from left to right along a horizontal line. For optimum reading efficiency, the distance of a cell to its neighbor on the same line should be 0.250 of an inch as measured from any dot center in one cell to the dot center of corresponding position in the neighboring cell. The horizontal measurement of a standard sheet of braille paper is 11-1/2 inches and, depending on margin and binding requirements, a standard line of braille can accommodate from 36 to 40 cells.

In the Braille System, as in ordinary print, lines of braille are consecutive from the top to the bottom of the braille page. For optimum reading efficiency, the spacing of consecutive lines should be 0.400 of an inch, the measurement being made from the dot center of any cell on one line to the corresponding dot center of the corresponding cell on the neighboring line. The vertical measurement of a standard sheet of braille paper is 11 inches and, allowing for a safe upper and lower margin, can accommodate 25 lines of braille.

For periodical literature in braille, sheets having other measurements are used and, for this purpose, it is standard to use a 40-cell line and a 32- line page.

1.1.4 Transmission of Information

By selecting a sufficiently large number of symbols from among the 64 that are available, and by assigning to each symbol so selected the role of an equivalent print sign, the dot combinations of the Braille System can be made to convey intelligible information.

When the braille symbols are assigned the roles of letters, numbers, and marks of punctuation, the system is made to convey literary information. When the symbols are assigned the roles of mathematical or scientific symbols, such as signs of operation, signs of grouping, or signs of relationship, the system can be made to convey mathematical or scientific information. By specifying the means by which the braille symbols can convey the pitch, duration, or accent of a tone or combination of tones, the system is made to convey musical text.

The problem of making a precise transcription into braille cannot be solved by establishing a simple correspondence between the print signs and the braille symbols. The nature of some of the difficulties will be detailed presently. Problems of exact transcription still remain unsolved in each of the three fields referred to above, and the existing braille codes in these fields are under constant review.

1.2 Mechanical Means of Producing Braille

There are essentially three methods of producing braille, corresponding roughly to handwriting, typewriting, and the printing press methods of ordinary print. These methods are described in turn.

1.2.1 The Slate and Stylus

The braille slate consists essentially of two strips of metal. The length of each strip is the length of the braille line; the width of each is usually sufficient for the space of four braille lines. The two strips are rigidly hinged together at one end.

The lower strip contains hemispherical indentations which correspond in depth and in spacing to the specifications for the production of braille symbols as contained in sections 1.1.1 - 1.1.3. There is an indentation for each dot position of each cell of each line of the slate. The upper strip contains openings which are essentially rectangular, and each opening corresponds to a cell of the lower strip. When the slate is closed, the rectangular openings in the upper strip are superimposed on the cells of the lower. The sheet of paper to be embossed is placed between the two strips and is held in position by pins provided for this purpose.

The actual embossing tool is called a stylus. The stylus consists of a knob shaped so that it can be grasped firmly in the palm, and in which is imbedded a rigid pin. The point of this pin is rounded to the shape of a dot. By exerting vertical pressure, the stylus point will form a dot by forcing the paper into one of the indentations of the lower strip. To assist the user of the slate in the proper positioning of his stylus point, each rectangular opening of the upper strip is provided with small recesses, three along one side and three along the other, to guide the stylus point to a position directly above the desired indentation, now obscured by the intervening braille paper.

Writing with slate and stylus corresponds roughly to handwriting with pencil and paper. The following essential differences are, however, worth noting:

(1) The deformation of a sheet of braille paper, dot by dot, by the exertion of vertical pressure with a stylus requires a physical effort quite beyond that which is involved in the use of a pencil on paper. As a consequence, the speed of braille production by this method is considerably slower than the formation of script signs by pencil, and the prolonged use of this method brings on "writer's cramp" much sooner and impairs efficiency still further.

(2) Each braille symbol must be reversed in the left-right direction during the writing operation so that, when the paper is removed from the slate and turned over for reading, the symbols will appear in their proper unreversed orientation.

(3) The dots which are formed during the writing operation cannot be read by touch, so that the writer must rely almost entirely on his kinesthetic sensations in the formation of the symbols, and must be more than usually attentive in keeping his place.

1.2.2 The Braille Writer

The braille writer is a mechanism for the production of braille which corresponds quite closely to the typewriter. The peripheral equipment on both machines is quite similar. The Braille writer has a paper feed mechanism for moving the sheets in and out and for spacing from one line to the next. Left and right margins can be set, and there is an end-of-the-line warning bell. The movement of the carriage can be controlled by a backspacing key, as well as by a carriage releasing mechanism by which it is possible to position the carriage at any desired cell of the line.

The keyboard of the braille writer, however, consists of a single row of seven keys. The center key is the space bar, and its actuation causes the carriage to move forward one cell at a time without the production of any braille symbols. Each of the other keys corresponds to one of the six dot positions of the braille cell. Proceeding from the space bar leftward, the keys correspond to dot positions 1, 2, and 3 respectively. Proceeding from the space bar rightward, the keys correspond to dot positions 4, 5, and 6 respectively. Each key actuates a single pin whose point is rounded to the size and shape of the braille dot. The actuation of any of the six keys causes the associated pin to form a dot by forcing the paper into an indentation on the opposite side. In the braille writer, the six pins are beneath the paper while the matrix which contains the corresponding indentations is above the paper. The embossing is therefore effected on the upper surface of the paper where it can easily be sensed by the finger as well as by the eye. A braille symbol is formed by the simultaneous actuation of all the keys which correspond to the dot positions of that symbol. In this way,

a single stroke on the keyboard produces a complete braille symbol in one cell. At the same time, the escapement mechanism permits the carriage to move forward to the next cell position in anticipation of the next stroke.

The speed of operation of a braille writer is quite comparable to that attainable on a typewriter. Only one copy at a time can be effectively reproduced on a braille writer, contrasted with the possibility of using carbon paper in a typewriter for the production of several simultaneous copies.

It is of interest to note that the braille writer antedates the typewriter, and that the former served as an inspiration for the invention of the latter.

1.2.3 Methods of Braille Duplication

For rapid reproduction and wide distribution of braille literature, neither of the methods just described is suitable. The principal method of braille duplication involves the use of two pieces of equipment — the stereograph machine and the braille press.

The stereograph is similar in construction and operation to that of a braille writer. However, since it is designed for embossing through a double thickness of sheet metal, it is electrically powered to insure the necessary force behind the pins which form the dots. The metal used for embossing is zinc, and each sheet of metal is called a zinc plate. After being embossed, each zinc plate contains raised dots on one side, and the corresponding indentations on the other.

The braille press is a device for exerting pressure on the two zinc plates between which has been placed a blank sheet of braille paper. When such pressure is applied, the dots of one plate cause the paper to be embossed by forcing it into the corresponding indentations of the other plate.

It is possible to emboss both sides of a pair of zinc plates by a process called interpointing. This is accomplished by offsettingthe pair of plates by a suitable amount both in the horizontal and the vertical direction when they are reinserted into the stereograph machine for embossing the second side. The offsetting causes the dots on the second side to be formed without interfering with those formed on the first side. When blank paper is pressed between zinc plates embossed by the interpointing process, the result is a sheet of paper which is embossed on both sides. Interpointing has not been successful either on the slate or in the braille writer because no practical method has been found to hold the paper sufficiently rigid for the time required to emboss it completely. As a result, the dots formed on the second side of the sheet often obliterate, either partially or completely, the dots previously formed on the first side.

The speed of operating the stereograph machine is considerably slower than the speed with which a braille writer can be operated because of the great power required for the deformation of the zinc plates and the consequent slowness in the clutch mechanism. The maximum speed attainable is 250 strokes per minute, which corresponds to about 50 words per minute. The rate of duplication by the braille press is also comparatively slow, and there is no system of high-speed braille printing comparable to any used by book or newspaper publishers.

There are other methods of duplicating braille which will not be described here. The principal disadvantage of most of the alternative processes is that only a limited number of legible copies can be produced, and that even these often contain dots which are either insufficiently high for efficient reading, or which are of non-uniform height.

1.2.4 Semi-Automation of the Braille Printing Process

In recent years, a beginning has been made toward the improvement of the braille printing process. A significant advance in this direction was made when the International Business Machines Corporation designed and built equipment by which it is possible to operate the stereograph machine by mechanical means rather than by a human operator. The equipment functions as follows:

(1) A human operator simulates the transcription into braille of a text on a keypunch machine whose keyboard is arranged like that of a braille writer. Instead of forming braille dots, however, this device produces punches either in cards or on continuous paper tape, and these punches are in one-to-one correspondence with the symbols which must eventually be embossed as the final product.

(2) The punched cards or paper tape are then subjected to a verification process. Here, a second human operator again simulates the transcription into braille of the same text. In this case, however, the verifier mechanism only "senses" the punches previously produced by the first operator, but makes no punches of its own. As long as the punch pattern produced by the first operator is in complete agreement with the sensing pattern set up by the second operator, verification is allowed to proceed, the presumption being that the transcription is, in such a case, correct. As soon, however, as there is a discrepancy between the punch pattern and the sensing pattern at any symbol, the presumption is that an error has been made and the verification is locked. In this case, the second operator must decide whether the error has been made in the verification process or in the original transcription process. If the operator decides that the error has been made in the verification process, the mechanism is merely unlocked and verification is permitted to proceed. If, however, the operator has decided that the error has been made in the original transcription, the necessary correction is made, after which the verification procedure continues. Corrections at this point are much easier to make than in the direct plate-making process, where corrections can only be made by the physical deformation of the plates by using special tools designed for the purpose.

(3) When the verification process has been completed, the resulting cards or paper tape, now presumed to be error-free, are loaded into a <u>reader</u>. There are available both a card reader and a tape reader. The stereograph machine is then actuated under the control of one of these readers and is made to emboss the zinc plates in accordance with the punches on the cards or on the tape. In this way, stereograph machines can be made to run for long periods of time at maximum speed, inasmuch as human fatigue is not a factor. The keypunch machines which produce the cards or tape can, moreover, be operated at the speed of a braille writer, thereby still further speeding up the printing process. An attendant is still required to replace plates or to turn them over, and to load or remove the punched cards or tape from the reader.

It is crucial that this process still involves two operators, each with a knowledge of the Braille System. Such operators must undergo a long training period to do this work at all, and they must have had long experience to develop the skill and accuracy necessary for efficient and sustained production. These factors add materially to the already large cost of braille printing. The extreme dearth of braille literature is attributable, in large measure, to this factor.

Other systems, not here described, are under research and development.

1.3 English Braille

In section 1.1.4, three kinds of text were distinguished — literary, technical, and musical. This investigation is confined, however, to literary texts and, more particularly, to those in the English language. Complete uniformity of opinion has not been achieved among the English-speaking peoples even now. After a long evolutionary process, there was published in this country a work entitled ENGLISH BRAILLE — AMERICAN EDITION, 1959. The American Edition part of this title is intended to suggest that the rules for the writing of English Braille set forth therein are those which are intended to be followed in the United States and that they differ in some respects from those which are followed, say, in the United Kingdom. The above work was published under the authority of the two principal professional organizations in work for the blind in this country — the American Association of Instructors of the Blind, and the American Association of Workers for the Blind. It is available both in braille and in print from the American Printing House for the Blind, Louisville, Kentucky. Since ENGLISH BRAILLE — AMERICAN EDITION, 1959 is the currently authorized set of rules in this country, it is used as the basis for the present investigation. The rules in this work are not repeated here, and the reader who wishes to follow the details of the discussion presented in later sections should avail himself of a copy for reference. Hereafter, the initials E.B. signifying English Braille will be used when referring to this work.

1.3.1 Historical Background

While the braille symbols used today for the letters of the alphabet are essentially those proposed by Louis Braille himself, this was not always the case. Two major deviations were attempted in this country. Both were officially abandoned in 1918 in favor of Louis Braille's original alphabetic symbols. The deviant systems were known as New York Point and American Braille.

1.3.1.1 New York Point

This system of dot embossing owes its name to the fact that it was devised at the New York Institute for the Education of the Blind almost a century ago and was used there for many decades, gradually gaining wider use with the passage of time. Its main feature is a cell in which there are two dots in the vertical direction and three in the horizontal direction. It has been well established by experiment that a dot combination in today's cell of three dots vertically and two horizontally can be perceived immediately by the finger without the need to make exploratory movements for the purpose of bringing peripheral dots into the center of discrimination. For this reason, a cell which is only two dots high fails to utilize tactual discrimination to its greatest efficiency. The resulting excessive cell length of three dots required arm movements over correspondingly longer distances to obtain the same information with an attendant more rapid rate

of fatigue.

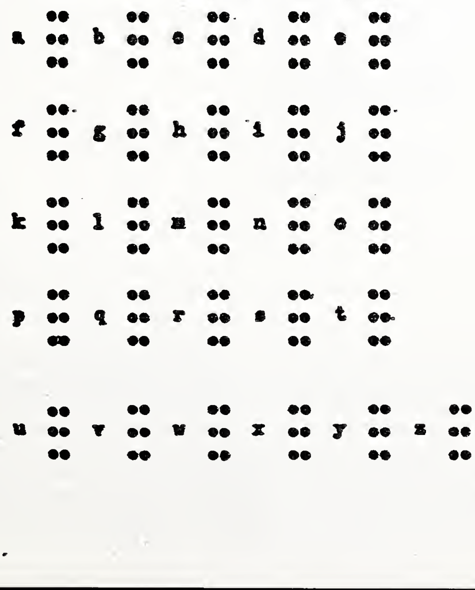
1.3.1.2 American Braille

This system owes its name to the fact that the United States is the only country where it was ever used. While it employs a cell having the same dimensions as is used in today's English Braille, it was based on the principle that letters of frequent occurrence should be represented by braille symbols with a small number of dots, and that letters of more infrequent occurrence should be represented by braille symbols with a greater number of dots. The result was that, very often, words and even whole phrases were composed of braille symbols in which the dots were so sparse that the positions of the dots within the cells could not be quickly perceived. The net result was a reduction in the reading rate.

1.3.2 The Letters of the Alphabet

In English, as in all languages which use the Latin alphabet, the symbols of line 1 (see section 1.1.2) have been assigned, respectively, the meanings of the letters from a to j. The symbols of line 2 have been assigned, respectively, the meanings of the letters from k to t. The first symbols of line 3 have been assigned, respectively, the meanings of the letters u, v, x, y, and z. The last symbol of line 4 has been assigned the meaning of the letter w. The letters of the alphabet and their corresponding braille symbols are as follows:

TABLE 2
THE LETTERS OF THE ALPHABET



The displacement of the letter w out of its alphabetic order is explained by the fact that, in the time of Louis Braille, this letter was not part of the French alphabet and he consequently made no provision for it. When, later, the need for this letter arose, an arbitrary symbol had to be chosen.

The reader is referred to E.B. and, in particular, to the introductory section entitled Alphabet and Numbers.

Words are separated merely by leaving a blank space between them. The practice of leaving two blank spaces at the end of a sentence is not carried over into English Braille. A new paragraph begins with the indentation of two blank spaces, the first symbol of the paragraph appearing in the third cell of the braille line.

1.3.3 Signs of Composition

There are six signs of composition in English Braille, and a seventh one devised for the purposes of this investigation. Each conveys information of a special nature in accordance with the rules of English Braille. No sign of composition is, of itself, equivalent to any sign of print. The functions of these signs is described below and in the next section. The signs of composition are as follows:

TABLE 3
SIGNS OF COMPOSITION

accent sign	●● ●● ●●	number sign	●● ●● ●●
capital sign	●● ●● ●●	termination sign	●● ●● ●● ●● ●● ●●
italic sign	●● ●● ●●	transposition sign	
letter sign	●● ●● ●●		

In print, the capitalized letters are distinct in form from the lower case letters. In addition, both lower case and capitalized letters are capable of modification by printing them in italic type, in boldface type, and in other type variations. While there is theoretically no limit to the number of distinct signs in print, there are but 64 distinct braille symbols. Therefore, the problem of representing the letters of the alphabet in all their variant forms cannot be met by the assignment of braille symbols in a one-to-one fashion. Instead, the problem is met by the introduction of certain braille symbols called signs of composition.

One of these is the capital sign. The rules governing its use are contained in E.B., section 9. A reading of this section reveals that the principal problem to be solved is that of making specific the extent to which the capital sign is effective, particularly in the case of the double capital sign.

A second sign of composition is the italic sign. The rules governing its use are contained in E.B., section 10. As with the capital sign, the principal problem is that of making specific the extent to which the italic sign is effective. In addition, however, it will be noted that the judgment of the transcriber plays an important part in the determination of whether or not this composition sign is to be used. Furthermore, the designation italic sign is only generic and applies to boldface type, underlined words, and, in general, to any variation of type form used for the purpose of distinction or emphasis. The braille reader is thus not aware of the precise print form which has been used for distinction or emphasis, but only of the fact itself. Finally, it should be noted that there is no provision for distinguishing between two types of emphasis, as when boldface type occurs within an italicized passage. In this investigation, the double italic sign listed as a separate sign of composition in E.B. is regarded as the succession of two single italic signs.

A third sign of composition is the termination sign. The rules governing its use are contained in E.B., section 14. Its principal function is to make specific the extent of the effectiveness of the capital sign and of the italic sign.

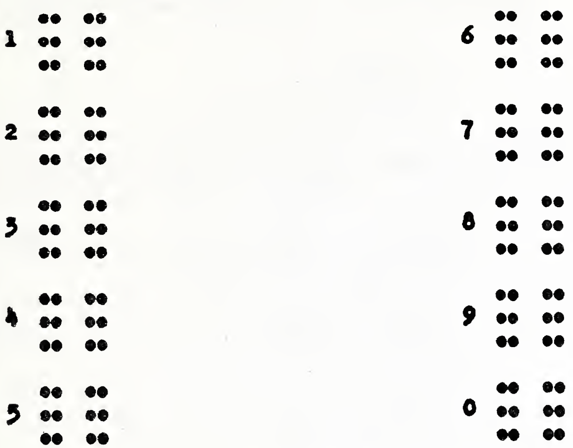
A fourth sign of composition is the accent sign. The rules governing its use are contained in E.B., sections 24 and 26. Even when letters retain their usual printed forms, they are sometimes modified by an accent mark. Although there is provision in the Braille System for the accent marks and special punctuations of the more common foreign languages (see E.B., Appendix B), in English Braille, only the presence of an accented letter is indicated and not the nature of the accent itself. This is accomplished by using the accent sign to precede the letter which it affects. The braille reader is thus unaware of the position of the accent mark relative to the letter which it affects, as well as being unaware of its precise nature.

The reader is referred to E.B., and in particular, to the introductory section entitled Punctuation and Composition Signs.

1.3.4 Numbers

In addition to having the meanings of the letters from a to j, the symbols of line 1 also have the meanings of the digits. In order to distinguish between the two meanings which these symbols have, a fifth sign of composition, called the number sign is used. The rules governing its use are contained in E.B., sections 28-31. Most of these rules are again concerned with the extent to which the number sign is effective. In addition, however, some deliberate deviations from print practice are recommended, particularly in the placement of abbreviations. The digits, together with their required number sign, are shown below:

TABLE 4
NUMBERS



The reader is referred to E.B. and, in particular, to the introductory sections entitled Alphabet and Numbers and Punctuation and Composition Signs.

A sixth sign of composition is the letter sign. The rules governing its use are contained in E.B., section 12. The letter sign has two principal functions:

(1). To distinguish between letters and numbers;

(2) To distinguish between letters and contractions.

In its first role, the letter sign terminates the effect of the number sign in a sequence of braille symbols containing numbers followed by letters. In this respect, the letter sign has a function like that of the termination sign.

The reader is referred to E.B. and, in particular, to the introductory section entitled Punctuation and Composition Signs.

In this investigation, a seventh composition sign has been devised and is called the transposition sign. There is no braille symbol to represent it. In E.B., section 31, there is the rule which requires that abbreviations of coinage, weight, and other measures be transposed so that they appear in braille before the number to which they pertain, whether or not this is the case in print. The use of this sign of composition between the number and the abbreviated word for coinage, weight, or other measure which follows it will cause this abbreviation to be transposed so that, in the enciphered product, it will occur before the number and thus meet the requirements of this rule.

1.3.5 Punctuation.

The punctuation marks of English Braille are represented by the use of symbols from lines 5, 6, and 7. All the punctuation symbols except the virgule are lower signs. The punctuation marks are shown below:

TABLE 5
PUNCTUATION.

Punctuation Mark	Sign	Symbol	Punctuation Mark	Sign	Symbol
apostrophe	'	●● ●● ●●	long dash	——	●● ●● ●● ●● ●● ●● ●● ●● ●● ●● ●● ●●
asterisk	*	●● ●● ●● ●● ●● ●●	period	.	●● ●● ●●
colon	:	●● ●● ●●	question mark	?	●● ●● ●●
comma	,	●● ●● ●●	right bracket	]	●● ●● ●● ●● ●● ●●
ellipsis	...	●● ●● ●● ●● ●● ●● ●● ●● ●●	right inner quote	’	●● ●● ●● ●● ●● ●●
exclamation point	!	●● ●● ●●	right outer quote	”	●● ●● ●●
hyphen	-	●● ●● ●●	right parenthesis	)	●● ●● ●●
left bracket	[	●● ●● ●● ●● ●● ●●	semicolon	;	●● ●● ●●
left inner quote	‘	●● ●● ●● ●● ●● ●●	short dash	—	●● ●● ●● ●● ●● ●●
left outer quote	“	●● ●● ●●	two dots	..	●● ●● ●● ●● ●● ●●
left parenthesis	(	●● ●● ●●	virgule	/	●● ●● ●●

The rules for the use of punctuation marks are contained in E.B., sections 1-7. The following points should be noted:

(1) There is no difference between the braille symbols for the left and right parentheses. There is also no difference between the braille symbols for the left outer quote and the question mark. In these cases, the meaning of the symbol is dependent upon the context.

(2) As in print, the symbols for the left and right brackets, parentheses, inner quotes, and outer quotes are pairs of symmetric symbols.

(3) The judgment of the transcriber is required in the use of some of the punctuation marks. Some deviations from print practice are also recommended.

The reader is referred to E.B. and, in particular, to the introductory section entitled Punctuation and Composition Signs.

A number, word, letter, or abbreviation may be under the simultaneous influence of more than one composition sign, and marks of punctuation may also be associated with such an expression. A definite order of precedence must therefore be established for the placement of composition signs and punctuation marks. This order of precedence is specified in E.B., section 8.

1.3.6 Signs of Arithmetic

In English Braille, there is provision for seven signs of arithmetic. These are shown below:

TABLE 6
SIGNS OF ARITHMETIC

Sign of Arithmetic	Sign	Symbol	Sign of Arithmetic	Sign	Symbol
cent sign	¢		paragraph sign	¶	
decimal point	.		percent sign	%	
degree sign	°		section sign	§	
dollar sign	$				

There is no separate listing of these signs in E.B., but the rules which govern them are contained in sections 28 and 31 of that work. The virgule is

used for the fraction line. The paragraph sign and the section sign are classified here because they obey the same rules as the other signs of arithmetic. The following points concerning the signs of arithmetic are worth noting:

(1) No provision exists, in English Braille, for representing the plus sign, the minus sign, the multiplication sign, the division sign, or the equals sign which occur so commonly in print. These signs are replaced by the words which are used for them when reading aloud. (See E.B., section 28 j).

(2) Abbreviated units of coinage, weight, and other measures precede the affected number in English Braille, whether or not this is the practice in print. (see E.B., section 31).

(3) The letter combinations for abbreviating gram, meter, and mile are different from those accepted as standard abbreviations for scientific purposes. (see E.B., section 31).

1.3.7 Contractions

A contraction is a braille symbol or combination of symbols which is equivalent to a larger number of print signs. A contractable combination is a combination of print signs to which there has been assigned a contraction. Except for the contractable combination o'clock, contractable combinations contain only letters.

Contractions were introduced into English Braille in an attempt to reduce the space occupied for braille text and to increase the reading rate. Experience has shown that the contractions of English Braille are effective in reducing the number of cells that would be required for uncontracted braille by about 20%.

When the contractions are added to the letters, numbers, signs of composition, marks of punctuation, and signs of arithmetic described in the foregoing sections, the resulting system is known as English Braille, Grade Two. The system without the contractions is known as English Braille, Grade One. Except when very young children are just learning braille, English Braille, Grade Two is used exclusively. Therefore, the braille transcriber must learn the contractions and the elaborate set of rules which govern their use in addition to the basic system of English Braille, Grade One.

There are 176 distinct contractions in English Braille, Grade Two. Of these, 52 are one-cell contractions, 48 are two-cell contractions, and 76 are short-form contractions. Of the 52 one-cell contractions, 13 have exactly two meanings, depending upon the rules of English Braille, Grade Two, and on the context. Each of the 48 two-cell contractions and 76 short-form contractions has exactly one meaning. There are thus 13 more contractable combinations than there are contractions — that is, there are 189 contractable combinations in English Braille, Grade Two. E.B. makes no distinction between contractions and contractable combinations and refers to both as contractions. The distinction is left to the reader. The contractable combinations are classified as follows:

(1) Whole words having one-cell contractions. — There are 35 contractable combinations in this category. To 23 of these there correspond contractions which are also letters of the alphabet; to 6 others there correspond contractions which are lower signs. The contractable whole words in this category are shown in the following list together with their corresponding contractions.

TABLE 7A
WHOLE WORDS HAVING ONE-CELL CONTRACTIONS

as	⠿	it	⠿	still	⠿
but	⠿	just	⠿	that	⠿
by	⠿	knowledge	⠿	this	⠿
can	⠿	like	⠿	to	⠿
child	⠿	more	⠿	us	⠿
do	⠿	not	⠿	very	⠿
enough	⠿	out	⠿	was	⠿
every	⠿	people	⠿	were	⠿
from	⠿	quite	⠿	which	⠿
go	⠿	rather	⠿	will	⠿
have	⠿	shall	⠿	you	⠿
his	⠿	so	⠿		

(2) Part words having one-cell contractions. — There are 23 contractable combinations in this category. Of these, 10 have contractions which are lower signs. The list follows;

TABLE 7B
PART WORDS HAVING ONE-CELL CONTRACTIONS

r	●● ●● ●●	dis	●● ●● ●●	ing	●● ●● ●●
b	●● ●● ●●	ea	●● ●● ●●	ou	●● ●● ●●
le	●● ●● ●●	ed	●● ●● ●●	ow	●● ●● ●●
c	●● ●● ●●	en	●● ●● ●●	sh	●● ●● ●●
h	●● ●● ●●	er	●● ●● ●●	st	●● ●● ●●
com	●● ●● ●●	ff	●● ●● ●●	th	●● ●● ●●
con	●● ●● ●●	gg	●● ●● ●●	wh	●● ●● ●●
d	●● ●● ●●	gh	●● ●● ●●		

(3) Part or whole words having one-cell contractions. — There are 7 contractable combinations in this category. Of these, two have lower signs. The list follows:

TABLE 7C
WHOLE OR PART WORDS HAVING ONE-CELL CONTRACTIONS

and	●● ●● ●●	for	●● ●● ●●	of	●● ●● ●●	with	●● ●● ●●

TABLE 7C (continued)
WHOLE OR PART WORDS HAVING ONE- CELL CONTRACTIONS

e	•• •• ••	in	•• •• ••	the	•• •• ••

(4) Whole words having two-cell contractions. — There is only 1 contracta-
le combination in this category. It consists of two lower signs. It is shown
elow:

TABLE 7D
WHOLE WORD HAVING TWO-CELL CONTRACTION

nto	•• •• •• •• •• ••

The 66 contractable combinations in the above four categories are listed in .B. in the introductory section entitled <u>one-Cell Whole-Word and Part-Word igns</u> where they are shown according to the contractions rather than according to he contractable combinations. The contractable combination <u>into</u>, although it as a two-cell contraction, occurs in this list.

(5) Initial-Letter contractable combinations. — There are 33 contractable ombinations in this category. To each, there corresponds a two-cell contracion. In each contraction, the first symbol is the second, third, or fourth symol of line 7. The second symbol in each contraction is either the letter or the art word contraction with which the contractable combination begins; hence the esignation <u>initial-letter</u>. These are listed below as well as in E.B. in the ntroductory section entitled <u>Initial-Letter Contractions</u>.

TABLE 7E
INITIAL-LETTER CONTRACTIONS

annot	•• •• •• •• •• ••	many	•• •• •• •• •• ••	some	•• •• •• •• •• ••	under	•• •• •• •• •• ••
haracter	•• •• •• •• •• ••	mother	•• •• •• •• •• ••	spirit	•• •• •• •• •• ••	upon	•• •• •• •• •• ••
ay	•• •• •• •• •• ••	name	•• •• •• •• •• ••	their	•• •• •• •• •• ••	where	•• •• •• •• •• ••

TABLE 7E (continued)
INITIAL-LETTER CONTRACTIONS

ver	●● ●● ●● ●● ●● ●●	one	●● ●● ●● ●● ●● ●●	there	●● ●● ●● ●● ●● ●●	whose	●● ●● ●● ●● ●● ●●
'ather	●● ●● ●● ●● ●● ●●	ought	●● ●● ●● ●● ●● ●●	these	●● ●● ●● ●● ●● ●●	word	●● ●● ●● ●● ●● ●●
ad	●● ●● ●● ●● ●● ●●	part	●● ●● ●● ●● ●● ●●	those	●● ●● ●● ●● ●● ●●	work	●● ●● ●● ●● ●● ●●
ere	●● ●● ●● ●● ●● ●●	question	●● ●● ●● ●● ●● ●●	through	●● ●● ●● ●● ●● ●●	world	●● ●● ●● ●● ●● ●●
now	●● ●● ●● ●● ●● ●●	right	●● ●● ●● ●● ●● ●●	time	●● ●● ●● ●● ●● ●●	young	●● ●● ●● ●● ●● ●●
ord	●● ●● ●● ●● ●● ●●						

(6) Final-letter contractions. — There are 14 contractable combinations in this category. Each corresponding contraction requires two cells. In each contraction, the first symbol is the fifth, sixth, or seventh symbol of line 7. The second symbol in each contraction is the letter with which the contractable combination ends; hence the designation final-letter. These are listed below as well as in E.B. in the introductory section entitled Final-Letter Contractions.

TABLE 7F
FINAL LETTER CONTRACTIONS

lly	●● ●● ●● ●● ●● ●●	ful	●● ●● ●● ●● ●● ●●	ness	●● ●● ●● ●● ●● ●●	ount	●● ●● ●● ●● ●● ●●
nce	●● ●● ●● ●● ●● ●●	ity	●● ●● ●● ●● ●● ●●	ong	●● ●● ●● ●● ●● ●●	sion	●● ●● ●● ●● ●● ●●
ation	●● ●● ●● ●● ●● ●●	less	●● ●● ●● ●● ●● ●●	ound	●● ●● ●● ●● ●● ●●	tion	●● ●● ●● ●● ●● ●●
ence	●● ●● ●● ●● ●● ●●	ment	●● ●● ●● ●● ●● ●●				

(7) Short-form contractions. — There are 76 in this category. Short-form ontractions are formed from combinations of letters or part word contractions hich suggest the short-form contractable combination to which they are equivaent. Short-form contractions occupy from two to five cells. They are listed elow as well as in E.B. in the introductory section entitled Short-Form Words.

TABLE 7G
SHORT-FORM CONTRACTIONS

bout	⠿ ⠿	herself	⠿ ⠿ ⠿
bove	⠿ ⠿ ⠿	him	⠿ ⠿
ccording	⠿ ⠿	himself	⠿ ⠿ ⠿
cross	⠿ ⠿ ⠿	immediate	⠿ ⠿ ⠿
fter	⠿ ⠿	its	⠿ ⠿
fternoon	⠿ ⠿ ⠿	itself	⠿ ⠿
fterward	⠿ ⠿ ⠿	letter	⠿ ⠿
gain	⠿ ⠿	little	⠿ ⠿
gainst	⠿ ⠿ ⠿	much	⠿ ⠿
lmost	⠿ ⠿ ⠿	must	⠿ ⠿
lready	⠿ ⠿ ⠿	myself	⠿ ⠿ ⠿

TABLE 7G (continued)
SHORT-FORM CONTRACTIONS

lso	●● ●● ●● ●● ●● ●●	necessary	●● ●● ●● ●● ●● ●● ●● ●● ●●
lthough	●● ●● ●● ●● ●● ●● ●● ●● ●●	neither	●● ●● ●● ●● ●● ●● ●● ●● ●●
ltogether	●● ●● ●● ●● ●● ●● ●● ●● ●●	o'clock	●● ●● ●● ●● ●● ●● ●● ●● ●●
lways	●● ●● ●● ●● ●● ●● ●● ●● ●●	oneself	●● ●● ●● ●● ●● ●● ●● ●● ●●
ecause	●● ●● ●● ●● ●● ●●	ourselves	●● ●● ●● ●● ●● ●● ●● ●● ●● ●● ●● ●●
efore	●● ●● ●● ●● ●● ●●	paid	●● ●● ●● ●● ●● ●●
ehind	●● ●● ●● ●● ●● ●●	perceive	●● ●● ●● ●● ●● ●● ●● ●● ●● ●● ●● ●●
elow	●● ●● ●● ●● ●● ●●	perceiving	●● ●● ●● ●● ●● ●● ●● ●● ●● ●● ●● ●● ●● ●● ●●
eneath	●● ●● ●● ●● ●● ●●	perhaps	●● ●● ●● ●● ●● ●● ●● ●● ●●
eside	●● ●● ●● ●● ●● ●●	quick	●● ●● ●● ●● ●● ●●
etween	●● ●● ●● ●● ●● ●●	receive	●● ●● ●● ●● ●● ●● ●● ●● ●●
eyond	●● ●● ●● ●● ●● ●●	receiving	●● ●● ●● ●● ●● ●● ●● ●● ●● ●● ●● ●●
blind	●● ●● ●● ●● ●● ●●	rejoice	●● ●● ●● ●● ●● ●● ●● ●● ●●

TABLE 7G (continued)
SHORT-FORM CONTRACTIONS

braille	[illegible]	rejoicing	[illegible]
children	[illegible]	said	[illegible]
conceive	[illegible]	should	[illegible]
conceiving	[illegible]	such	[illegible]
could	[illegible]	themselves	[illegible]
deceive	[illegible]	thyself	[illegible]
deceiving	[illegible]	today	[illegible]
declare	[illegible]	together	[illegible]
declaring	[illegible]	tomorrow	[illegible]
either	[illegible]	tonight	[illegible]
first	[illegible]	would	[illegible]
friend	[illegible]	your	[illegible]
good	[illegible]	yourself	[illegible]

TABLE 7G (continued)
SHORT-FORM CONTRACTIONS

great	⠿⠿⠿	yourselves	⠿⠿⠿⠿

Associated with all these contractions is an elaborate set of rules most of which can be found in E.B., sections 34-47. Additional rules can, however, also be found in some of the earlier sections at appropriate places.

For the most part, the rules are classified in the same way as are the contractions themselves. Thus, Rule XI deals with contractable whole words with one-cell contractions, Rule XII with contractable part words with one-cell contractions, Rule XIV with initial-letter contractions, Rule XV with final-letter contractions, and Rule XVI with short-form words. Within these rules there are many specific regulations concerning individual contractions. Nevertheless, some of the rules cut across these classifications. Thus, Rule XIII deals with lower signs regardless of the contraction classification to which they belong, as well as in their capacity as marks of punctuation and signs of composition. Rule X is an over-all statement of principles to be followed in the use of any contraction.

Although the rules have been prepared with a good deal of care, and liberally illustrated by examples, doubtful applications and exceptions occur from time to time because of the complexities and unusual letter combinations in the English language. For this reason, a list of Typical and Problem Words (see E.B.) has been included for the benefit and guidance of the braille user.

1.3.8 Format and Specialized Text

Although the arrangement of braille material follows, as far as possible, the usages of print, limitations of space, as well as other factors, require some deviation from precise conformity.

Title pages and other introductory materials are standardized in format as specified in E.B., section 15. Page numbering is also standardized as described in E.B., section 16. Indented paragraphing without intervening blank lines is the only kind permissible; block form with intervening blank lines is discouraged as wasteful of space. These matters are taken up in E.B., section 18. Ornamental lettering at the beginning of a chapter is not represented in braille, nor are embellishments of any kind.

Illustrations and diagrams are, except in textbooks, for the most part omitted. Tabular material may be either omitted altogether or modified for presentation in braille form within the limits of the braille page. Even the wording of the associated text may require alteration by the editor for proper reference. Such matters are dealt with in E.B., section 19, and Appendix A, section 5. Footnotes, as well as references of all types may require the editor's special attention as described in E.B., sections 21-23.

Special symbols have been devised for indications of scansion and stress in poetry as described in E.B., section 33, for representations of diacritical and phonetic marks which show correct stress and pronunciation, described in E.B., Appendix C, sections 1-2, and for the precise specification of accented letters and special punctuation marks in the more common foreign languages, described in E.B., Appendix B.

Special formats are recommended for the transcription of poetry in E.B., Appendix A, section 2, and for the transcription of other special materials such as plays, outlines, and test materials. These matters are discussed in E.B., Appendix A, sections 6-8.

1.3.9 Space Requirements

It was noted earlier that a standard page of braille can accommodate 25 lines. Since it is also standard practice to employ a 36-cell line in books which are press brailled, a standard braille page can accommodate 900 cells. By comparison, a typical page of print can, depending upon type size and page size, accommodate about 65 signs per line and about 45 lines per page. The capacity of a page of print is thus seen to be about 2,900 signs. This is a ratio of a little more than three pages of braille per page of print. By the use of contractions, however, this ratio can be reduced to about 2-1/2 pages of braille per page of print.

If we take into account the fact that the dimensions of the standard braille page are 11 X 11-1/2 inches, and that the dimensions of a typical page of print are about 5-1/2 X 8-1/2 inches, a simple calculation shows that 0.146 of a square inch per braille symbol is required compared with 0.016 of a square inch per print sign. This is a ratio of about 9 signs of print per braille symbol.

The thickness of braille paper required for embossing, together with the height of the dots on the finished product are additional factors contributing to the large physical size of braille text. A typical volume of interpointed braille is about 2-3/4 inches thick and contains about 220 pages (110 leaves). By comparison, a printed book is about 1-3/4 inches thick and contains about 500 pages (250 leaves). To transcribe such a printed book into braille would require seven typical interpointed braille volumes. The space occupied by the braille text would be about 2,435 cubic inches compared with about 82 cubic inches for the printed copy. This is a ratio of about 30 cubic inches of braille per cubic inch of printed text.

The high cost of braille books and the almost prohibitive amount of space required for their storage are the principal reasons that blind people own very few of their own braille books. Instead, these are borrowed from regional libraries for the blind, the selections being made from a catalogue of available titles. The books themselves pass through the mails free of postage under special act of Congress.

1.3.10 Availability of Braille Matter

The amount of reading matter in braille is minute when compared with the huge amounts of reading materials of all kinds which are available in print.

Reading matter in braille is made available in two principal ways -- by

raille press, in multiple copies, through funds allocated for this purpose by he Library of Congress; and in single copies produced by volunteer braille tranoribers on the braille writer or the braille slate after a training course in nglish Braille, Grade Two, leading to certification by the Library of Congress.

In 1960, a typical year, the Library of Congress furnished 150 titles in raille. These titles catered to all groups and interests — juvenile and adult, iction and non-fiction. These were placed in 32 regional libraries for the lind throughout the country with 3 to 15 copies deposited in each, depending pon the area and population served.

In this same period, volunteer transcribers produced about five times as any titles, in single copies which were either placed in the regional libraries or the blind or directly into the hands of the blind person requesting the ranscription. Because of the incomplete reporting of volunteer efforts, the umber of titles which they produced is only an estimate.

.4 The Problem of Automatic Encipherment of English Braille, Grade Two

In section 1.2.4, some of the more recent developments were described which ake for the semiautomation of the braille printing process. It was pointed out hat two human operators, each with training in the Braille System, were reuired for making the original transcription and for proofreading it by the erification process.

With the advent of high-speed digital computers and their application to he problem of language translation, the possibility for using such a device for he purpose of making the encipherment into English Braille, Grade Two, fully autoatic readily suggests itself. It is the realization of this possibility which s the principal subject matter of this investigation.

.4.1 Comparison of Language Translation with Braille Transcription

When a particular word or phrase of one language is being translated into the words or phrases of another, the rendering depends not merely upon the words themselves, but also upon the preceding and succeeding words. It may therefore be said that language translation is a context-dependent transformation. In like manner, an examination of the rules which govern the writing of English Braille, Grade Two, will reveal that the use or avoidance of most of the contractions depends upon the letter groups or punctuation marks which precede or follow the contractable combination. In this sense, then, the encipherment of English Braille, Grade Two, may also be considered to be a context-dependent transformation.

In the case of a language, the unit of context is generally taken to be the sentence. A grammatical and syntactical analysis of the words therein must be undertaken before a decision can be made about the rendering of any particular word or phrase. In braille, the unit of context is most advantageously taken to be a word or a number together with the associated marks of punctuation and the space or spaces which follow it. Thus, a longer segment of information must generally be available for examination when translating a language than when making a transcription into braille. Nevertheless, at least two rules of braille depend upon the wider context of the sentence for their proper implementation. The two rules are those contained in E.B., sections 37 and 41. Both of these rules are

oncerned with the possibility of omitting the space after certain words of common ocurrence and joining them directly to the following word "if there is no natural ause between them".

In the Braille System, there is a space, 26 alphabetic symbols, 22 marks of unctuation, 7 signs of composition, 7 signs of arithmetic, and 176 contractions – a total of 239 representations in braille. If we regard these as consitituting he "vocabulary" of English Braille, Grade Two, this number is considerably less han the ordinary vocabulary required in the translation of a language, or even f the restricted vocabulary required for specialized or technical subject atter. On the other hand, a language translation may be considered to be adeuate if it conveys the essential sense of the original, even if it does so at he expense of good grammar and sentence structure. On the contrary, a braille ranscription must follow faithfully all the rules which have been set down, if t is to be acceptable at all. This requirement alone causes the decision-making etwork to be more elaborate in the encipherment of English Braille, Grade Two, han in the translation of a language.

The rules of grammar in any language are the result of analysis and discovery and are therefore not subject to modification, except by the normal evoluion of the language itself. With the numerous exceptions, irregularities, and dioms which occur, the implementation of many of the rules of grammar in a igital computer can only be effected by extension, that is, by the storage of ong lexicographic tables and their equivalents in the computer memory. On the ther hand, the rules, and even the symbols and representations of the Braille ystem are the result of pronouncement by duly constituted authorities. As such, hey are subject to frequent amendment, modification, and additions by these same uthorities. Since the rules of braille are under constant review, it is coneivable that future modifications will be made with ease of computer impleentation in mind, and without in any way being detrimental for other purposes. t present, however, many of the rules of braille resemble those of grammar in a anguage in that they require the storage of suitable tables in the memory of the omputer for their proper implementation. This situation is likely to persist or some time, however, since E.B. is a recent work whereas its predecessor ears a publication date of 1951.

.4.2 System of Braille Production with Automatic Encipherment

As has just been stated, the transfer of the skill of a human operator with knowledge of English Braille, Grade Two, to a digital computer is the principal im of this investigation. But unless this is made a part of a larger system, it annot result in the actual production of braille material. The overall system, t the heart of which is the digital computer, will be described in the following ections.

.4.2.1 The Printed Text

As has already been specified, this investigation is restricted to texts in he English language. There are, however, certain additional restrictions with espect to the kind of text which can be handled by the digital computer. The ollowing kinds of text are excluded:

(1) Poetry in which the text contains indications of stress or meter. However, ordinary poetry is not excluded.

(2) Text material, such as dictionaries, grammars, or spellers, which contain a considerable amount of diacritical marks or phonetics.

(3) Tables, illustrations, charts, graphs, and materials of a similar nature. Although such materials are not handled directly by the digital computer, the editor of the braille text can arrange to leave enough lines or pages blank for their insertion at a later time by a human operator.

(4) Texts involving the use of scientific or technical notation, with the exception of such signs which are a part of the general literature and in common use.

(5) Deferred text, such as footnotes, marginal notes or end-of-chapter references, in which the reference indication is contained in the body of the text but the reference itself is deferred to the end of the page or of the chapter. The editor may permit such references, if short, to be interpolated into the text, or may arrange to leave enough lines blank at the bottom of the page, or enough pages blank at the end of the chapter for their insertion at a later time by a human operator.

(6) Music staff notation.

Text materials of the kind just excluded constitute only a smlll part of the total literature, so that their exclusion does not constitute a significant restriction of the utility of this method of encipherment.

1.4.2.2 The Editor

To meet the special format requirements of the braille text, some of which have already been mentioned in section 1.3.8, and for other purposes as well, it is necessary to have the attention of a person with a knowledge of the problems that may arise, and with skill and experience in dealing with them. Such a person is called the editor.

The editor scans the printed text and when a situation appears therein requiring special braille treatment, the editor makes an indication to the transcriber as to how that situation is to be handled in braille. If the printed text is being prepared for automatic encipherment, the editor's task, in some situations, such as in items (3) and (5) above (section 1.4.2.1) is to calculate the number of lines or pages of braille to be left blank so that material can be inserted later by a human operator, and then instruct the transcriber to leave this space blank. To the editor fall the following specific tasks:

(1) To indicate the points in the printed text at which braille volumes should terminate. The experience of the editor will permit these places to be designated in advance in such a way that each braille volume will be of suitable length, and the volumes will all be of approximately equal size.

(2) To specify whether a running head is to be included. The running head is simply the title of the printed text. When it is used, it occupies the top line of braille on all pages to the right of the binding. In the case of interpointed material, this means that the running head appears at the top of each odd-numbered braille page. The running head is frequently omitted for space-saving reasons. Since a typical braille page contains 25 lines, a 4% loss is incurred on each page on which it is used. If the editor specifies that a running

head is to be used, the actual braille symbols for the running head must be supplied as well as the number of braille cells which it occupies. The editor may designate that a permanent heading appear on the last line of each braille page or of each odd-numbered braille page instead of on the top line.

(3) To specify the type of page numbering to be used. In most cases, the page numbers of the printed text are ignored and the braille pages are numbered consecutively. In other cases, particularly in the transcription of textbooks, the braille pages are identified by using the page numbers of the printed text from which the transcription is made. This permits the braille reader to refer to the same page numbers as do his colleagues who use the printed text.

(4) To specify the number of cells per line and thereby establish the line margin. It was mentioned in section 1.1.3 that the standard sheet of braille paper contains from 36 to 42 cells per line, but the editor must specify the exact number.

(5) To reserve the space required for tables, figures, charts, graphs, and references which must later be inserted by a human operator.

(6) To decide on the omission of material difficult or impossible to reproduce in braille, such as pictures, colored plates, and three-dimensional drawings., and to make whatever modifications are necessary in the associated text as the result of such omissions.

(7) To point out to the transcriber which words or phrases are foreign and which therefore require transcription into Grade One, without the use of contractions.

(8) To point out to the operator any material which must be transcribed by specifying the dot numbers of the component braille symbols. This situation might arise in the transcription of syllabized words where the usual rules for contractions are not applicable. (See E.B., section 13 d). In such cases, the editor must supply the dot numbers of the symbols to be transcribed in this manner.

(9) Upon the advent of each centered caption, to determine the minimum number of lines which must remain on the braille page to insure that the centered caption and the text which must follow it appear on the same braille page. This number must be reported to the transcriber.

The editor must, of course, be aware of the format controls available to the transcriber in order to supply the proper instructions and of a kind which can be implemented by the computer. Accordingly, the editor is referred to section 1.4.2.3 where the functions of the transcriber are completely described.

1.4.2.3 The Transcriber

The transcriber is the person who copies the printed text by operating a device which produces information of a kind acceptable to a digital computer. In this investigation, the device operated by the transcriber is the IBM 024 keypunch which produces punched cards. Accordingly, the transcriber will hereafter be referred to as the keypunch operator or briefly as the operator. Devices which might be used in a parallel system include the tape-punching machine which produces punches on continuous paper tape, or a device which "writes" on magnetic tape.

he following points concerning the keypunch operator should be noted.

(1) A prerequisite skill is the ability to use an ordinary typewriter. he operation of the keypunch is, in many respects, similar to the operation f a typewriter, and the skill is quickly and easily transferred.

(2) The operator is subject to the instructions supplied by the editor as escribed in section 1.4.2.2.

(3) Besides the space, the 26 letters, and the 10 digits, the keypunch is quipped to make only 11 additional punches called <u>special character punches</u> (see .4.2.4, SPECIAL CHARACTER KEYS). Since it is necessary to represent 7 signs of omposition, 22 punctuation marks, and 7 signs of arithmetic, the operator must earn a number of compound key combinations devised in this investigation to make hese representations possible. In each compound key combination, the components re exclusively special character keys. The complete list of key combinations hich the operator must learn in order to transcribe these representations is resented below.

TABLE 8
KEY COMBINATIONS

<u>SPACE AND ALPHABET</u>
(as on a typewriter)

<u>DIGITS</u>
(see section 1.4.2.4, NUMERIC KEYS)

<u>COMPOSITION SIGNS</u>

ccent sign	▬/	letter sign	▬*	termination sign	▬.
apital sign	▬	number sign	▬$	transposition sign	▬▾
talic sign*	▬▾				

<u>PUNCTUATION</u>

postrophe	$▾	left inner quote	$*	right inner quote	$/
sterisk	*	left outer quote	$(	right outer quote	$)
olon	$.	left parenthesis	(	right parenthesis	)
omma	,	long dash	▾▾▾▾	semicolon	$,
llipsis	...	period	.	short dash	▾▾
xclamation point	$$	question mark	$▬	two dots	..
yphen	▾	right bracket	$-	virgule	/
eft bracket	$+				

---

*In this and in succeeding tabular material, the hyphen will be distinguished rom the minus sign by using the sign ▾ for the hyphen, and the sign - for the inus sign.

TABLE 8 (continued)
KEY COMBINATIONS

SIGNS OF ARITHMETIC

ent sign	+-	dollar sign	+$	percent sign	+/
ecimal point	+.	paragraph sign	+)	section sign	++
egree sign	+*				

(4) The operation of the keypunch is essentially the transcription of in-
ormation in one "dimension". The operator must therefore learn some additional
ey combinations devised in this investigation for controlling the disposition
f information on a two-dimensional braille page. Among such control require-
ents are paragraphing, line skipping, page skipping, and caption centering. A
ew additional key combinations have also been devised for controlling the manner
n which information is interpreted or handled. These the operator must also
earn. The complete list of such key combinations is presented below under the
eneric name of format control.

TABLE 8 (continued)
KEY COMBINATIONS

FORMAT CONTROL

raille control	-*	line control	-.	page control	-)
entering control	-/	numbering control	--	space control	-$
ot control	-(	outline control	-+	volume control	-,

The function of each of these controls will be described below (see section
.4.2.3.1).

(5) Some of the rules of English Braille require the judgment of the oper-
tor for their proper implementation. Such judgment does not entail decisions
oncerning the use or avoidance of contractions. They are primarily concerned
ith the proper use of punctuation marks, signs of composition, and abbreviations.
he instructions to the operator are concerned with such matters and are contained
n section 1.4.2.3.1. In addition, these instructions are also concerned with the
roper use of format controls and these matters are also dealt with in section
.4.2.3.1.

While it is thus clear that the operator must undergo special training in
rder to operate the keypunch in a manner which will result in proper encipher-
ent into English Braille, Grade Two, such training is not more rigorous than
hat which is undertaken by typists in specialized fields. It is certainly far
ess than the training required to acquire the skill in the direct transcription
f English Braille, Grade Two.

1.4.2.3.1 Instructions for the Guidance of the Operator

The following set of instructions is intended as a reference and sort of manual for the operator and the proofreader. It should also become familiar to the editor.

These instructions are divided into three main sections. The first section deals with punctuation, the second with signs of composition, and the third with format controls. Within each section, the items are alphabetized for easy reference.

1.4.2.3.1.1 Instructions Concerning Punctuation

(1) For a list of the 22 punctuation marks, see section 1.4.2.3, TABLE 8.

(2) When there are two or more consecutive marks of punctuation, the operator must, in general, preserve the order in which these punctuation marks appear in the printed text. For an exception, see QUOTATION MARKS, item (1).

(3) Marks of punctuation must, in general, precede any composition signs which may be simultaneously required. For exceptions, see APOSTROPHE, item (4), and HYPHEN, item (6).

(4) If a mark of punctuation ends a sentence, the operator must, in conformity with the practice on the typewriter, leave two spaces before continuing to keypunch any new information.

APOSTROPHE

(1) If the apostrophe is missing before the s in the formation of the plural of a letter, number, or abbreviation, the operator must supply the apostrophe. Ex.:

If the text shows	copy the text as if it showed
Xs	X's
1930s	1930's
ABCs	ABC's

(2) If the apostrophe is missing before the d in OK'd, the operator must supply the apostrophe. Ex.:

If the text shows	copy the text as if it showed
OKd	OK'd

(3) The operator must supply the apostrophe in the interjection h'm! even if it is missing in the print. Ex.:

If the text shows	copy the text as if it showed.
hm!	h'm!'

(4) If an italicized word or number begins with the apostrophe, the operator must keypunch the italic sign before keypunching the apostrophe. Ex.,

f the text shows, in italic type	The text should be keypunched as
Tis true.	=-$.=TIS =-TRUE.
he gay '90's.	=THE =-GAY =-$.90$.S.

STERISK

(1) The operator must use the asterisk only for the purpose of making a eference indication and for no other purpose.

(2) The only punctuation which may precede the asterisk is the left paren- hesis or the left bracket. In every other case, the asterisk must be preceded y at least one space.

(3) The only representation which may follow the asterisk is a number hich specifies the note number to which reference is made. In all other cases, he asterisk must be followed by at least one space.

(4) If the reference indication is associated with the last word of the entence, the period or other punctuation mark which terminates the sentence must e punched after that word and not after the asterisk, regardless of whether or ot this practice is followed in the printed text.

(5) The operator must use the asterisk as a reference indicator even if ther reference indicators, such as the dagger, are used in the printed text. To istinguish between one reference indication and another, the operator must punch ppropriate identifying numbers after the asterisk.

(6) The operator will generally be guided by the editor in the proper use f the asterisk.

LLIPSIS

(1) When a series of dots is used in print to indicate the omission of a ord or phrase, or even the omission of a whole sentence or paragraph, the opera- tor must use three consecutive periods regardless of the number of dots used in he printed text to show the omission.

(2) When a series of asterisks is used in print to indicate omitted ma- terial, the operator must avoid the distinction between the dots and the asterisks nd must use the three consecutive periods as in item (1) above.

(3) When omitted material is indicated in the printed text by the use of the long dash, the operator must likewise use the long dash and not the ellipsis.

(4) When, in print, the purpose of a series of dots or a series of asterisks s ornamentation, such dots or asterisks must not be copied by the operator.

(5) When, in print, the purpose of a series of dots or of asterisks is to show the passage of time, or to show a change of mood or scene, such dots or asterisks must not be copied by the operator. Instead, the operator must indicate by means of <u>line control</u> that a line is to be skipped (see section 1.4.2.3.1.3, LINE CONTROL).

(6) Punctuation marks which precede or follow the ellipsis should be adjoined to the ellipsis without any intervening space. When four consecutive dots appear in print for the purpose of indicating omission, the fourth dot must be regarded by the operator as the period and keypunched accordingly. If a new sentence begins in the same paragraph directly after the four periods, the operator must leave two spaces after the last of the periods before beginning a new sentence.

(7) When letters within a word are omitted and this omission is shown by a series of dots, the operator must use a period for each omitted letter; Ex.:

<u>The name</u>	<u>should be keypunched as</u>
N... Y...	=N.. =Y....

(8) When the omission of an entire paragraph is shown by dots in the printed text, the operator must begin a new paragraph by using linecontrol and then keypunching two spaces, after which the three dots must be keypunched. This having been done, the operator must begin another paragraph.

HYPHEN

(1) If the sole purpose of the hyphen is to divide a word between syllables in order to continue it on the next line, the operator must ignore the hyphen and punch the word as if it were not present. Ex.:

<u>The divided word</u>	<u>should be keypunched as</u>
mys- tery	MYSTERY

However, if the hyphen is part of a genuine compound word, the operator must retain such a hyphen. Ex.:

<u>The compound word</u>	<u>must be keypunched as</u>
self-control	SELF-CONTROL

(2) No space may be left on either side of the hyphen in a genuine compound word. However, if the first part of a compound word is not followed immediately by the second,, one space must be left after the hyphen. Ex.:

<u>THE COMPOUND EXPRESSION.</u>	<u>should be keypunched as</u>
five- or six-pointed star	FIVE- OR SIX-POINTED STAR

(3) When letters within a word are omitted and this omission is shown in print by the use of hyphens, the operator must supply as many hyphens as there are missing letters. There must be no space between any letters of the word and a hyphen used in this way, nor may a space be used to separate consecutive hyphens. Ex.:

<u>The suppressed word</u>	<u>must be keypunched as</u>
d--n	D--N

(4) The operator must ignore the hyphen in the words <u>to-day</u>, <u>to-morrow</u>, and <u>to-night</u> even if it is present in print.

(5) The operator must not confuse the hyphen with either the short or the

ong dash. The operator must also be careful not to use the 11-punch to repre-
ent the hyphen.

(6) The hyphen should generally be supplied by the operator between the apitalized and uncapitalized portions of a word, or between the italicized and nitalicized portions of a word. Ex.:

he word	should be keypunched as
nSELFish	UN.==SELF.ISH
eelect	RE.=-ELECT
igar	=-CI.GAR

owever, if the hyphen which is introduced in this way after the capitalized or talicized portion of a word might give the erroneous impression that the word is enuinely compound, the operator must use the termination sign instead of the yphen. Ex.:

he word	must be keypunched as
ASEball	==BASE=.BALL

f the hyphen is already present in the printed text after the capitalized or talicized portion of a word, the operator must supply the termination sign, and his composition sign must precede the hyphen. Ex.:

he word	must be keypunched as
hite-collar	=-WHITE=..COLLAR

(7) The hyphen must be replaced by the short dash when punching sports cores, vote counts, and similar number comparisons. Ex.:

he expression	must be keypunched as
3-7	13..7
03-13	403..13

(8) The operator must supply the hyphen between the whole number and the ractional portion of a mixed number if one is not already present in the printed ext. Ex.:

he mixed number	must be keypunched as
$\frac{1}{2}$	2.1/2

(9) The operator must use the hyphen in telephone numbers between the ex- hange designation and subscriber's call number, no matter how these are separated n the printed text. Ex.:

he telephone number	must be keypunched as
H6:1234	==CH6.1234

ONG DASH

(1) When the dash is used to indicate the omission of a word or name, the perator must use the long dash. The long dash must then be spaced and punctuated s if it were the omitted word or name itself. (See E.B., section 6a and, in articular, the example).

(2) See also HYPHEN, item (5).

PERIOD

(1) When the component numbers of a date are separated by the period in the printed text, the operator must replace such a period by the hyphen. Ex.:

The date	must be keypunched as
8.9.36	8-9-36

(2) The operator must not use the period instead of the decimal point.

QUOTATION MARKS

(1) Sometimes the roles of the inner and outer quotation marks are interchanged in the print. The operator must ignore such alternative usage of quotation marks and must supply outer and inner quotation marks and not single and double quotation marks. Ex.:

The expression	must be keypunched as
'Sing "Homing."'	$(=SING $*=HOMING.$/$)

(2) When quoted matter is indicated in the printed text by a change to smaller type or to italicized type, or by a change of format, such as the indentation of the quoted matter, the operator must ignore these variations in type and format but must supply the quotation marks if they are missing from the printed text.

(3) When quotation marks are used in the printed text for setting apart of single letters, the operator must omit these quotation marks when making the transcription. Ex.:

The expression	must be keypunched as
Make an "X."	=MAKE AN =X.

SHORT DASH

(1) When the dash is used to indicate hesitation, or to set apart an explanatory or subordinate thought within a sentence, the operator must use the short dash. (See E.B., section 6 and, in particular, the two examples).

(2) Within the same sentence, the operator must not leave any space on either side of the short dash even if such spacing is present in the printed text. But a space may precede the short dash at the beginning of a sentence or follow it at the end of a sentence. Ex.:

The sentence	must be keypunched as
It was -- as a rule -- easy.	=IT WAS--AS A RULE--EASY.

(3) See also HYPHEN, items (5) and (7).

VIRGULE

(1) When the component numbers of a date are separated by the virgule, the operator must replace such a virgule by a hyphen. Ex.:

The date	must be keypunched as
8/9/36	8-9-36

(2) When the virgule is used to separate two denominations of English money, the operator must replace the virgule bv the number sign. Ex.:

The amount	must be keypunched as
s16/6	S16=$5

(3) The operator must use the virgule to replace the horizontal line which separates the numerator from the denominator of a fraction. Ex.:

The fraction	must be keypunched as
$\frac{1}{3}$	1/3

1.4.2.3. .2 Instructions Concerning Signs of Composition

(1) For a list of the seven signs of composition, the operator should consult section 1.4.2.3, TABLE 8.

(2) When the operator is required to use two or more composition signs consecutively, the order of these signs must be as shown below:

a. Italic sign (single or double),
b. Letter sign
c. Capital sign (single or double),
d. Accent sign.

(3). When the operator is required to use both punctuation marks and signs of composition consecutively, the order of these signs must be as shown below:

a. Except as indicated below, punctuation marks must precede signs of composition.
b. The apostrophe must follow the italic sign.
c. The hyphen must follow the termination sign.

Ex.:

The italicised expressions	must be keypunched as
Etude 43	==-=/ETUDE =-43
'Tis true.	=-$-TIS =-TRUE.

(4) The italic sign precedes a sign of arithmetic. Ex.:

the italicized expressions	must be keypunched as
$2.98	=-+$2+.98
§2	=-++2
¶B	=+)=B
.02	=-+.02

ACCENT SIGN

(1) If a letter in the printed text is accented, regardless of the precise accent mark used, or of its position above or below the affected letter, the operator must use the accent sign before the letter concerned. Ex.:

The words	must be keypunched as
café	CAF=/E
garçon	GAR=/CON
blessèd	BLESS=/ED
señor	SE=/NOR

(2) The operator must ignore the accented o, if present, in words such as cooperate, coordinate, and role.

CAPITAL SIGN

(1) The capitalization of a single letter must be indicated by the operator by the use of the capital sign before the letter. Ex.:

The words	must be keypunched as
I am	=I AM
O'Connor	=O$-=CONNOR

(2) The capitalization of a whole word or group of letters must be indicated by the operator by the use of two capital signs. These are used before the word or group of letters to be capitalized. Ex.:

The expressions	must be keypunched as
THE LORD	==THE==LORD
SOS	==SOS

When a word consists of a single letter, only one capital sign must be used. Ex.:

The words	must be keypunched as
A	=A
I	=I
O	=O

(3) The double capital sign must not be repeated after the hyphen in a capitalized compound word. Ex.:

The compound word	must be keypunched as
SELF-MADE	==SELF-MADE

If an apostrophe occurs within a capitalized word, the double capital sign must not be repeated after the apostrophe. Ex.:

The expressions	must be keypunched as
P'S AND Q'S	==P$-S ==AND ==Q$-S
O'CONNOR	==O$-CONNOR

(5) In a group of capitalized letters with intervening periods, the opera-
r must use the capital sign before each letter. Ex.:

e abbreviation	must be keypunched as
M.	=P.=M.

(6) When capitalized Roman numerals are joined by the hyphen, the single double capital sign must be used after the hyphen according as the number of tters which follows the hyphen is one, or more than one. Ex.:

e Roman numerals	must be keypunched as
VI	=V.==VI
-X	==VI.=X

(7) If all the letters of a proper name beginning with Mc or Mac are capi-lized, but the ac or the c is in smaller type, the ac or the c must be regarded uncapitalized and the name treated accordingly. Ex.:

e names	must be keypunched as
cDONALD	=MAC==DONALD
CARTHY	=MC==CARTHY

(8) A number must never be capitalized, even if it occurs in a title. Ex.:

e title	must be keypunched as
,000 YEARS IN SING SING	20,000==YEARS==IN==SING==SING

(9) When the capitalization of a word or phrase is for the purpose of dis-nction or emphasis, the operator must use the representation for the italic gn instead of the capitalization indicator.

(10) The operator must ignore the ornamental capitalization of a word or quence of words in the first paragraph of a new chapter. In such a situation, oper paragraph indentation should be used and only the first letter of the rd should be capitalized.

ALIC SIGN

(1) The presence of italic type in print does not, in every case, re-ire the operator to indicate this fact. The following are the conditions under ich italic print must be indicated.

a. When it is used to indicate emphasis in speech. Ex.: If you are going to go, go.

b. When it is used to distinguish between the body of the text and a foreign or anglicized word or phrase therein. Ex.: an a priori condition.

c. When it is used before abbreviations. Ex.: viz., i.e., etc.

d. When it is used to designate the names of books, ships, works of art, etc. Ex.: Read EAST SIDE, WEST SIDE.

e. When it used to specify a subject heading at the beginning of a para-graph.

f. When it is used to distinguish between conversation and silent thought.

g. When it is used to distinguish between the speaking lines in a play and the stage directions or settings.

The following are some conditions under which italic print must not be indicated by the operator:

a. When it is used in addition to, or instead of, quotation marks. In this situation, the operator must supply the quotation marks if they are not already present.

b. When it is used in addition to parentheses to indicate the pronunciation of a word. In this situation, the operator must retain the parentheses.

c. When an entire passage is italicized and is set apart from the rest of the text by skipped lines or by a line of periods or asterisks. In this situation, the operator must indicate a skipped line on both sides of such a passage.

d. When it is used to indicate single letters.

e. When it is used in connection with centered captions.

(2) Boldface type, underlined words, and other types of print should be regarded as italic type and the operator must use the italic sign or avoid its use in accordance with the same conditions as in item (1) above.

(3) To indicate that a single word, number, or abbreviation is in italic type, the operator must use the italic sign before such a word, number, or abbreviation. Ex.:

The italicized expressions	must be keypunched as
disgraced	=-DISGRACED
1066	=-1066
e.g.	=-E.G.

(4) If an italicized word contains the hyphen or the apostrophe, the operator must not use the italic sign after the hyphen or the apostrophe. Ex.:

The italicized expressions	should be keypunched as
l'orange	=-L$=ORANGE
o'clock	=-O$=CLOCK
blue-eyed	=-BLUE=EYED
out-of-the-way	=-OUT=OF=THE=WAY
1914-1918	=-1914=1918

However, the short dash terminates the effect of a single italic sign.

(5) When more than three consecutive words belonging to the same passage must be italicized, the operator must use the double italic sign before the first word and the single italic sign before the last word of such a passage. Ex.:

The italicized expressions	must be keypunched as
The House of Representatives	=-=-=THE =HOUSE OF =-=REPRESENTATIVES
It was a sad home-coming!	=-=-=IT WAS A SAD =-HOME=COMING$$

(6) If it is necessary to indicate that an entire passage consisting of ore than one paragraph is in italic type, the operator must use the double italic ign before the first word of each paragraph, but the single italic sign must be ised only once before the last word of the last paragraph.

(7) A dash or ellipsis at the beginning or end of an italicised passage must e excluded from the effect of the italic sign.

(8) If each item in a list of title, ships, works of art, etc., must be talicized, the operator must use the double italic sign before the first word of ach item (even if it contains fewer than four words), and the single italic sign nly once before the last word of the last item. The presence of such words as nd or or must not be interpreted as breaking the consecutive nature of the ist. (See E.B., section 10 e).

LETTER SIGN

(1) When the single letter a refers to the letter of the alphabet and is not the indefinite article, the operator must supply the letter sign before the a. Ex.:

<u>The expressions</u>	<u>must be keypunched as</u>
A is a vowel	=*=A IS A VOWEL
The first letter is a.	=THE FIRST LETTER IS =*A.

(2) The operator must use the letter sign when referring to the capitalised letter I. Ex.:

<u>The expression</u>	<u>must be keypunched as</u>
The ninth letter is I	=THE NINTH LETTER IS =*=I.

The letter sign must not be used before a capitalised I, however, if it is part or all of a Roman numeral. Ex.:

<u>The Roman numerals</u>	<u>must be keypunched as</u>
I	=I
II	==II
III	==III
IV	==IV
IX	==IX

(3) When Roman numerals are represented in the printed text by lower case letters, the operator must supply the letter sign before the first letter or each Roman numeral so represented. If two Roman numerals are joined by the hyphen, the operator must supply the letter sign after the hyphen but before the first letter of the second Roman numeral. Ex.:

<u>The Roman numerals</u>	<u>must be keypunched as</u>
i	=*I
ii	=*II
i-iv	=*I,=*IV
ii-v	=*II,=*V
ii-vi	=*II,=*VI

(4) When an ending is added to a Roman numeral, the operator must supply the letter sign before such an ending. Ex.:

The Roman numerals	must be keypunched as
XVa	==XV=*A
XVA	==XV=*=A
XV.a	==XV.=*A
XV.A	==XV.=*=A
XXIst	==XXI=*ST
Xth	=*X=*TH
Louis XIIIème	=LOUIS ==XIII=*=/EME

(5) If a single letter is joined to the following word by a hyphen, the operator must supply the letter sign before the single letter if both of the following conditions are satisfied.

a. The letter which follows the hyphen is the same letter as the one which precedes it;

b. The combination is not intended to represent stammering or stuttering.

Ex.:

The expressions	must be keypunched as
D-day	=*=D.DAY
B-box	=*=B.BOX
S-shaped	=*=S.SHAPED
c-clamp	=*C.CLAMP

In the following examples, the letter sign must not be supplied by the operator because condition a above is not satisfied. Ex.:

The expressions	must be keypunched as
I-beam	=I.BEAM
U-boat	=U.BOAT
V-neck	=V.NECK

In the following examples, the letter sign must not be supplied by the operator because condition b above is not satisfied. Ex.:

The expressions	must be keypunched as
B-but	=B.BUT
m-m-mother	=M.M.MOTHER

NUMBER SIGN

(1) See VIRGULE item (2).

(2) If the virgule is followed by a number in the representation of a model number, or serial number, the operator must supply the number sign after the virgule. Ex.:

The expression	must be keypunched as
Model 09/52	=MODEL 09/=$52

RMINATION SIGN

(1) See HYPHEN, item (6).

ANSPOSITION SIGN

(1) When an abbreviation of coinage, weight, or other measure follows a mber in the printed text, the operator must use the transposition sign instead the space between the number and the abbreviation which follows it. Ex.:

e expression	must be keypunched as
yd.	2=vYD.
) mph	30=vMPH.
),000 Kc/s	10,000=vKC/S.

(2) In punching the abbreviation which follows a number, the operator must e lower case letters regardless of whether the printed text uses capitalized tters or not. The period must always follow such an abbreviation whether or not period appears in the printed text. If an s is present in the printed text llowing such an abbreviation to form the plural, the operator must ignore the resence of the s used in this way. Ex.:

he expression	must be keypunched as
5 Ft	25=vFT.
Yds.	5=vYD.

.4.2.3.1.3 Instructions concerning the Control of Format and Information

(1) For a list of the nine format controls, the operator should consult ection 1.4.2.3, TABLE 8.

(2) Each format control must be preceded by at least one space. If the receding text was the end of a sentence, two spaces will be used.

(3) Each format control must be followed by at least one space before reuming text punching or the punching of another format control.

RAILLE CONTROL

(1) The operator must use this control only upon instruction by the ditor.

(2) If the editor specifies that Grade One must be used, the operator must unch the braille control representation followed by the number 1. If the editor pecifies that Grade Two must be used, the operator must punch the braille conrol representation followed by the number 2. Ex.:

f the editor specifies	the operator must punch
rade One	-*1
rade Two	-*2

Initially, the control is set for Grade Two.

(3) The editor may use this control for the interpolation of foreign phrases

or passages into the body of the text.

CENTERING CONTROL

(1) The operator must use the centering control in order to indicate that what follows is a caption requiring centering. The operator must also use the centering control in order to indicate that what precedes is a caption requiring centering. To effect proper centering, the operator must take the following steps:

a. Even before using the centering control, the operator must have used line or page control in order to insure that no part of the caption to be centered will appear on the same line of braille with any preceding material.

b. Inasmuch as line control and page control require that what follows must begin on a new card, the centering control by which centering is initiated must begin on a new card.

c. The operator then punches the representation for the centering control.

d. The operator then punches an 8 without an intervening space. This digit has the effect of making the centering control effective.

e. After the 8, the operator must punch the number of lines required by the editor. If this number of braille lines is still available on the braille page after the caption has been centered, centering will occur on the same braille page. If fewer lines than this number are available on the braille page, all the remaining lines on the braille page will be left blank and the centered caption will be placed on the first available line of the next braille page. If the editor has specified this number to be zero, this merely means that the caption should be centered on the braille page even if the centering occurs on the bottom line. This situation may arise on the title page, where all items are centered and where the last line of the page might be the date of publication. The operator must always represent the number of lines specified by the editor by making two punches. If the editor has specified fewer than ten lines, the first punch for this number must be 0.

f. The operator must then keypunch one space.

g. Following this space, the operator must keypunch the caption to be centered.

h. After the caption has been keypunched, the operator must keypunch two spaces.

i. After these two spaces, the operator must keypunch the representation for the centering control again.

j. After punching the representation for the centering control, the operator must punch the digit 9 without an intervening space. This digit makes the centering control ineffective.

k. The operator must then punch one space.

1. The operator must then use line control or page control in order to insure that no part of the text which follows the centered caption will occur on the same braille line with the caption.

Ex.:

If the centered caption is	and the editor specifies	THE OPERATOR MUST PUNCH
CHAPTER III	3 lines	-/303 --CHAPTER --III -/9

In the above example, it is understood that the representation for line control or page control has preceded the representation for the centering control on a previous card, and that the representation for line control or page control follows the last representation of the centering control with one intervening space. The number 3 specified by the editor guarantees that if one line is skipped after the centered caption, at least two lines of text will follow the centered caption on the same braille page.

(2) Most generally, the line controls which are used in connection with the centering control require that one line be skipped, but this is not necessary. The line control representations may require only the transition to the next line (without skipping any lines) or they may require the skipping of more than one line. It is the editor's function to specify the number of lines to be skipped if it is other than one line.

DOT CONTROL

(1) The operator must use this control only upon instruction by the editor. In turn, when the editor requires the use of this control, the dot numbers which must be keypunched by the operator must be supplied.

(2) When the editor requires that dot control be used, the operator must take the following steps:

a. The operator first punches the representation for dot control.

b. The operator then punches the digit 8 without an intervening space. The digit 8 makes dot control effective.

c. The operator then punches one space.

d. The operator then punches the numbers supplied by the editor, leaving one space between each group of numbers.

e. The operator must also leave one space after the last group of numbers.

f. The operator then punches the representation for dot control again.

g. The operator then punches the digit 9. The digit 9 makes dot control ineffective.

Ex.:

If the editor has instructed the operator to use dot control and has furnished the required dot numbers, and

the text shows	the operator keypunches
will-ing-ness	-(8 2456 24 123 123 36 346 36 1345 15 234 234 -(9

(3) If the editor wishes to leave a blank cell while dot control is effective, the number 0 should be supplied to the operator for this purpose.

(4) The editor must use this control, as in the example above, to assure the proper encipherment of syllabized words where the usual rules for making the contractions of English Braille, Grade Two, are not applicable. This control will also be found useful in texts whose subject matter is the Braille System itself.

(5) Initially, dot control is ineffective.

LINE CONTROL

(1) The operator must use line control for the following purposes:

a. To proceed to the next line. This will cause the following braille text to appear on the next line of the braille page if possible, and otherwise it will appear on the first available line of the next braille page.

b. To skip a specified number of lines. This number is generally one line between consecutive centered captions or between a centered caption and the following text. It is also generally one line where it is desired to indicate the passage of time, or a change of mood or scene, or when separating such items as letters or telegrams from the body of the text. However, the editor may specify any number of lines greater than one. In this situation, if there is an insufficient number of available lines on the braille page to meet the requirement, the difference will be made up by skipping an additional number of lines from those available on the next braille page until the requirement is met.

c. To wait until the top of the next braille page has been reached, and then skip a specified number of lines. In this situation, the editor must not specify more lines than the number available for skipping on a single braille page, since in that case line skipping will be confined to the braille page, and any additional line skipping will be ignored. This feature may be employed by the editor for interpolating tables into the text.

d. To wait until the top of the next odd-numbered braille page has been reached and then skip a specified number of lines. The same restriction applies here as in c above. This feature may be employed by the editor for the interpolation of diagrams or figures into the text which must appear on odd-numbered braille pages.

(2) To use line control properly, the operator must take the following steps:

a. The operator must first punch the representation for line control followed, without an intervening space, by the digit 8. This digit makes line control effective.

b. If the purpose of line control is to proceed to the next line, no additional punching is required, except as specified in f below.

c. If the purpose of line control is to skip a specified number of lines without waiting until the top of the next page, or of the next odd-numbered braille page, has been reached, the operator must continue to implement the control by punching an 8 followed by a 0. The operator must then punch the specified number of lines to be skipped. This number must always be represented by two punches, so that if the number is less than ten, the operator must first make a 0 punch. Then, see f below.

d. If the purpose of line control is to wait until the beginning of the next braille page before skipping a specified number of lines, the operator must proceed as in a, and then continue by punching a 9 followed by an 8. The operator must then punch the specified number of lines to be skipped, using two punches for this purpose. Then, see f below.

e. If the purpose of line control is to wait until the beginning of the next odd-numbered braille page before skipping a specified number of lines, the operator must proceed as in a above, and then continue by punching two consecutive 9's. The operator must then punch the specified number of lines using two punches for this purpose. Then, see f below.

f. In any case, the operator must then leave one space and keypunching must continue on the next card. This single space must be left even if it is the only punch on the card.

Ex.:

if it is first required to	the operator must punch
proceed to the next line	-.8
skip one line immediately	-.88001
skip two lines immediately	-.88002
skip 10 lines at top of next page	-.89810
skip 20 lines at top of next odd-numbered page	-.89920

(3) To end a paragraph and begin a new one, the operator must first use line control for proceeding to the next line, as described in (2) a and b above. After having initiated a new card, as required in (2) f above, the operator must punch two spaces. This will cause an indentation of the two spaces required at the beginning of the new paragraph.

(4) To begin a new line of poetry, the operator must use line control for proceeding to the next line as described in (2) and b above, After having initiated a new card as required in f above, the operator must keypunch the new line of poetry without leaving any initial spaces. It is assumed that when the operator begins a new line of poetry as just described, that outline control calls for poetry format. In this situation, any carry-over to the next braille line will cause that carry-over to be indented, usually by two spaces. Any other number of spaces for the indentation of carried over material may be specified by the editor.

(5) To begin a new stanza of poetry, the operator proceeds as in (4) above, except that line control is set for the skipping of one line.

(6) The operator is not required to terminate the effect of line control. is it automatically accomplished in the computer after the line control re-irements have been satisfied.

(7) If the top or the bottom line of the braille page is required to con-in a permanent heading, such a line is not counted as a skipped line in the plementation of line control. If a page number is required to occupy the ght-hand corner of the top line or of the bottom line of the braille page, ch a line is counted as a skipped line in the implementation of line control.

MBERING CONTROL

(1) The operator must use the numbering control for any of the following rposes.

a. To change the mode of page numbering from Roman numerals to Arabic numerals, and vice versa. In section 1.4.2.2 Item (5), reference was made to two kinds of page numbers -- braille page numbers and print page numbers. The numbering control is effective with each of these types.

b. To interrupt the sequential order of page numbers which is automatically maintained in the computer and to initiate a new sequence, beginning with a specified number. Numbering control can be used to interrupt the sequence of braille page numbers or of print page numbers.

c. To interrupt encipherment on the braille page in order to indicate to the braille reader that the material which follows is transcribed from the next page of the printed text.

(2) To use the numbering control properly, the operator must take the llowing steps:

a. The operator must first punch the representation for the numbering control.

b. If the numbering control is to have effect on braille page numbers, the operator must punch an 8. If the numbering control is to have effect on print page numbers, the operator must punch a 9. If the purpose of the numbering control is as in (1) c above, the operator need make no more punches except for the space which is required to follow any format control representation. If there is room on the braille page for at least two more lines of braille when this control is activated, the first of these lines will contain a series of braille guide dots at the end of which will appear the next print number in the sequence maintained in the computer; the second of these braille lines will be a continuation of the body of the text. If there are fewer than two lines on the braille page when this control is activated, the body of the text will continue on the next braille page without any guide dots, and the next print page number in the sequence maintained in the computer will be placed in the right-hand corner of the top line.

c. After punching the digit which controls the effect on braille or print pages, the operator then punches an 8 if the page number is to be in Arabic numbers and a 9 if it is to be in Roman numerals. In the case

hat Roman numerals are required, they will appear in lower case letters preceded by the letter sign. If, after this punch has been made, the operator makes no further punches except the space which must follow all format control representations, the sequence maintained in the computer will be replaced by a new sequence beginning with the number 1.

d. If it is required that the new sequence begin with a number other than 1, the operator must then punch the first number of the new sequence.

x. t:

If the editor has specified that braille page numbers are to be used and he operator has just finished keypunching the preface, the mode of page numbering must be changed from Roman to Arabic numberals. To accomplish this, the perator punches --89

If the editor has specified that print page numbers are to be used and the perator has just completed the keypunching of a page of the printed text, the perator must punch --9

If print page numbers are specified, and the operator has just finished eypunching the last of the material which appears on a printed page bearing a oman numeral, and if the material which follows begins on a printed page bearing he number 5, the operator must punch --985

UTLINE CONTROL

(1) Outline control is used for the following two purposes:

a. To initiate poetry format. In this format, each new line of poetry begins at the margin and any carry-over to the next braille line is indented. The number of indented spaces is usually two, but the editor may specify any other number. Poetry format is not necessarly confined to poetry, and may be used for the encipherment of material in outline form.

b. To initiate the right adjustment of a braille line. When this arrangement is required, each line of braille is terminated at the right margin and a sufficient number of spaces is automatically provided at the beginning of each line to accomplish this. The editor may use this control for the placement of dates or signatures at the right-hand end of the braille line.

(2) To initiate poetry format, the operator must take the following steps:

a. The operator must have used line control or page control in order to insure that no part of the text to be outlined appears on the same line of braille with any preceding material.

b. Inasmuch as line control or page control requires that what follows must be punched on the next card, the representation for outline control must be punched at the beginning of a new card.

c. The operator then punches the representation for outline control.

d. The operator then punches an 8 without any intervening space. The digit

8 makes outline control effective.

e. The operator then punches two more 8's. The purpose of the first 8 is to orient outline control toward poetry format rather than toward the right adjustment of braille lines. The purpose of the second 8 is to indicate . that what follows in the text is the beginning of a line of poetry, and not the continuation thereof.

f. The operator then punches the number of spaces to be indented if there is any carry-over of the line of poetry to the next braille line. This number requires two punches so that if fewer than ten spaces are to be indented, the first of these punches must be a 0. In the absense of any instruction from the editor, the operator must indicate that two spaces are to be indented, but the editor may specify any other number.

g. The operator must then leave one space.

h. The operator must then keypunch the text of the first line of poetry.

i. At the end of each line of poetry, the operator must leave one space if it is not the end of a sentence, and two spaces if it is the end of a sentence.

j. The operator must then use line control. If the line of poetry which follows belongs to the same stanza, line control will be punched so as to proceed to the next line. But if the line of poetry which follows begins a new stanza, line control will be punched so as to require the skipping of one line. In either case, the operator will then punch one space and then initiate a new card.

k. After the last line of poetry has been punched together with the space or spaces which follow it, the operator must punch the representation for outline control.

l. The operator must then punch the digit 9 without any intervening space. The digit 9 makes outline control ineffective.

m. The operator must then keypunch one space.

n. The operator must then use line control or page control in order to insure that the text which follows will not appear on the same line of braille with the last line of poetry.

x.g:

If poetry format is required	the operator must punch
ndenting two spaces for carry-overs	-+88802
ndenting 5 spaces for carry-overs	-+88805

(3) To initiate right adjustment, the operator must take the following teps:

a. As in (2) a above.

b. As in (2) b above.

c. As in (2) c above.

d. As in (2) d above.

e. The operator must then punch the digit 9. The purpose of this digit is to orient outline control toward right adjustment rather than toward poetry format.

f. The operator must then punch one space.

f. The operator must then punch the text of the material to be right adjusted.

h. The operator must then leave two spaces.

i. As in (2) k above.

j. As in (2) l above.

k. As in (2) m above.

l. As in (2) n above.

x. 8:

<u>If the right adjusted text is</u>	<u>the operator must keypunch</u>
.B.S.	-+89 =O.=B.=X. -+9

(4) It is not possible for outline control to require, simultaneously poetry format and right adjustment.

(5) While outline control is in effect, it is possible to use the centering control successfully. Thus, if a book of poetry is being transcribed, it is possible to center the titles of consecutive poems without first terminating and afterward reinstating the effectiveness of poetry format.

PAGE CONTROL

(1) The operator must use page control for any of the following purposes:

a. To proceed to the next page. This will cause all the remaining lines on the current braille page to be left blank and the following braille text will appear on the next braille page beginning with the first available line thereon.

b. To permit encipherment to continue until a specified line on the braille page has been completed and then to leave the remaining lines on that braille page blank. The text which follows continues on the next braille page. This provision is for the purpose of permitting footnotes to be inserted by a human operator later. The editor will have computed the number of braille lines required for the footnote, including the line which must separate the text from the footnote, and will then allow encipherment after the asterisk which signifies the footnote to continue until the required number of blank lines remain on the braille page.

If page control is used for this purpose when fewer than the required number of lines still remain on the braille page, the remaining lines, and one additional line, will be left blank at the beginning of the next braille page. The extra line is to allow the separation of

the text from the continuation of the footnote.

c. To wait until the current braille page has been completed and then skip a specified number of pages. This provision will be useful to the editor for the interpolation at a later time by a human operator of a table, chart, or figure.

d. To wait until an even-numbered braille page has been completed and then skip a specified number of pages. This provision will be useful to the editor for interpolating a drawing or other material of a nature which does not permit interpointing.

(2) To use page control properly, the operator must take the following steps:

a. The operator must punch the representation for page control and then, without an intervening space, punch an 8. The digit 8 makes page control effective.

b. If the purpose of page control is to proceed to the next page, no additional punching is required, except as specified in f below.

c. If the purpose of page control is to permit encipherment until a specified braille line on the braille page has been completed and then leave the remaining lines blank, the operator must continue to implement the control by punching an 8 followed by a 0. The operator must then punch the line number beyond which the encipherment on the same braille page must cease. This number requires two punches so that if the number is less than ten, the operator must first punch a 0. Then, see f below.

d. If the purpose of page control is to wait until the current page has been completed before skipping a specified number of pages, the operator must proceed as in a above and then punch a 9 followed by an 8. The operator must then punch the specified number of pages to be skipped, using two punches to represent this number. Then, see f below.

e. If the purpose of page control is to wait until the next even-numbered braille page has been completed before skipping a specified number of pages, the operator must proceed as in a above and then punch two 9's. The operator must then punch the specified number of pages to be skipped, using two punches to represent this number. Then, see f below.

f. In any case, the operator must then leave one space and punching must continue on the next card. This single space must be left even if it is the only space on the card.

Ex.s:

If it is required to	the operator must punch
proceed to the next page	-)8
encipher the first 17 lines only	-)88017
skip 5 pages when current page is finished	-)89805
skip 10 pages when next even-numbered page is finished	-)89910

(3) To end a chapter on one page and begin a new one on the following page, he operator must first use page control for proceeding to the next page as de-ribed in (2) a and b above. After initiating a new card as required in (2) f bove, the operator must use the centering control for centering the caption hich follows.

(4) The operator is not required to terminate the effect of page control; his is automatically accomplished in the computer after the requirements of age control have been satisfied.

PACE CONTROL

(1) The purpose of the space control is to permit a specified number of paces to intervene between two words on the same braille line. This number must e specified by the editor. The editor must be sure, when specifying this number, hat there is room on the braille line for the number of spaces specified.

(2) To use the space control properly, the operator must take the following teps:

a. The operator must first punch the space control representation.

b. The operator must then punch the number of spaces specified by the editor without any intervening space. Two punches are required for the representation of this number, so that if the number is less than ten, the operator must use the 0 as the first punch.

x.:

f the editor specifies	the operator must punch
eave 6 spaces	-$06

(3) The space before and after the space control is not counted. Only the ctual number of spaces specified will be left between the words on the same raille line.

(4) There is no need for the operator to terminate the space control.

OLUME CONTROL

(1) Volume control is used for any of the following purposes:

a. To terminate a volume of braille by affixing the centered caption:

END OF VOLUME ...

The ellipsis above represents the volume number which must be specified by the editor and punched by the operator.

b. To terminate a complete braille text by affixing the centered caption

THE END.

c. To terminate the braille text without affixing any centered caption whatsoever.

(2) For the proper use of volume control, the operator must take the lowing steps:

a. The operator must first punch the representation for volume control.

b. If a centered caption is required, as in a and b above, the operator must punch an 8 without any intervening space. If no centered caption is to be affixed, as in c above, the operator must punch a 9 without any intervening space.

c. After the operator has punched the 8 to indicate that a centered caption is to be affixed, the operator must punch the number of the volume being terminated. This number will be supplied by the editor. The operator must make two punches to represent this number, so that if the volume number is less than ten, the operator must punch a 0 as the first punch. If the operator punches no number at all after having punched the 8 to indicate that a centered caption is to be affixed, the centered caption

THE END.

will automatically be affixed.

d. If the operator has punched a 9 to indicate that no centered caption is to be affixed, no further punching is required.

s:

the editor has specified that	the operator punches
ume I should terminate	-,801
ume II should terminate	-,802
entire text should terminate	-,8
text should terminate without centered caption	-,9

(3) Volume control has the effect of initializing the program so that it may used to terminate encipherment at the end of any paragraph or line of poetry. program may then be recovered from the computer by "dumping" the drum. This formation may then be used at a later time to continue the encipherment.

(4) There is no need to terminate the effect of volume control on the rt of the operator.

.2.4 The Keypunch

In this investigation, the keypunch is the device for punching blank cards th information of a kind that can be handled by a digital computer. It is the 4 024 keypunch.

The operation of the keypunch is, in many respects, similar to the operaon of a typewriter. It is for this reason that the skill of typing can be adily transferred to the operation of the keypunch machine.

The keypunch is capable of producing punch patterns corresponding to the ace, 26 alphabetic characters, 10 numeric characters, and 11 special characters. addition, there are control keys for releasing, feeding, registering, and

duplicating cards. There are two shift keys — an alphabetic shift, and a numeric shift. These are located in the positions of the left and right shift key, respectively, of the ordinary typewriter. Their function, however, is not quite the same as the function of the shift key on the typewriter.

The space bar and the 26 alphabetic keys occupy the same position on the keypunch as on a typewriter. For this reason, the positions of those keys will not be listed here. It should be noted, however, that the alphabetic shift must be in effect in order to produce alphabetic punching. Inasmuch as most of the punching is alphabetic when copying literary text, the alphabetic shift is kept automatically in effect at all times but can at any time be overridden by the numeric shift under the control of the operator. Keeping the alphabetic shift automatically in effect at all times is one of the functions of the master card used in connection with the keypunch.

The numeric keys do not occupy positions along the upper bank as on a typewriter. Numeric punching is accomplished by using certain keys on the keyboard while holding down the numeric shift. The keys which produce numeric punching are as follows:

TABLE 9
NUMERIC KEYS

Digit	Numeric shift with	Digit	Numeric Shift with
0	virgule	5	K
1	U	6	L
2	I	7	M
3	O	8	period position
4	J	9	comma position

The virgule is one of the special characters which the keypunch is capable of producing and is located on the fourth bank of keys. Its precise position is indicated below, in connection with the discussion on special characters. With the alphabetic shift in effect, this key produces a punch pattern corresponding to the virgule, but with the numeric shift held down, it produces the punch pattern corresponding to the digit 0. The designations period position and comma position refer to the keys which, on the typewriter, would be the period and the comma respectively, but which, on the keypunch, do not have these roles.

The upper bank of keys consists of a left group of five keys, a middle group of three keys, and a right group of two keys. In each group, the left key is a control key. In addition, the right key of the right group of two keys is also a control key. If numbers are arbitrarily assigned from 1 to 6, proceeding to the right, to the keys which are not control keys, the following table shows the means of producing the special character punches:

TABLE 10
SPECIAL CHARACTER KEYS

Special Character	Symbol	Produced by
asterisk	*	alphabetic shift with key 3
comma	,	numeric shift with key 2
dollar sign	$	numeric shift with key 3
equals sign	=	numeric shift with key 1
hyphen	-	alphabetic shift with key 1
left parenthesis	(	alphabetic shift with key 2
minus sign	-	alphabetic shift with key 5

TABLE 10 (continued)
SPECIAL CHARACTER KEYS

Special Character	Symbol	Produced by
period	.	numeric shift with key 4
plus sign	+	numeric shift with P
right parenthesis	)	alphabetic shift with key 4
virgule	/	alphabetic shift with key 6

Because the alphabetic shift is automatically in effect, six of the special characters can be produced simply by actuating the proper key. The remaining five special characters must be produced by actuating the proper key with the numeric shift held down.

The hyphen and the minus sign may not be used interchangeably, since each produces a punch pattern distinct from the other.

For long production runs, the operation of the keypunch is facilitated by the use of a programmed master card. The master card controls the format on each card as it moves through the keypunch mechanism and also controls the movement of the cards. The operator can, however, at all times override the control of the master card by use of the control keys on the keypunch. Since the transcription of literary material entails punching which is predominantly alphabetic, the master card is programmed to keep the alphabetic shift automatically in effect. This means that all the alphabetic keys, the space, and six of the eleven special character keys can be used without the use of a shift key. The ten numeric keys and five of the special character keys must be used with the numeric shift held down.

The keypunch is used not only for punching the cards with the text material to be enciphered into braille, but it is also used for punching the cards with the instructions which the computer must execute to effect the encipherment. Cards which contain such instructions are called <u>program cards</u> or <u>load cards</u>. Cards which contain the text material are called <u>data cards</u>.

1.4.2.5 The Input Card

The input card contains 80 columns. There are twelve punch positions in each column, and these are numbered in descending order, from the top to the bottom of the card, 12, 11, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9. Each character key on the keypunch produces its own punch pattern. This punch pattern is confined to a single column, and it is therefore possible to produce a punch pattern in each of the 80 columns. The pattern is produced by punching a square hole into e ach punch position comprising the pattern. There are from 0 to 3 punches in each punch pattern. The space produces no punches and therefore results in a <u>blank column</u>. The characters and the punch patterns which are associated with them are shown below. A punch pattern is designated by specifying the positions in the card column in which punching occurs. The positions are named in descending order, from the top of the card to the bottom.

TABLE 11
PUNCH PATTERNS

Character	Punch Pattern	Character	Punch Pattern	Character	PunchPattern
SPACE	blank	P	11-7	5	5
A	12-1	Q	11-8	6	6
B	12-2	R	11-9	7	7
C	12-3	S	0-2	8	8
D	12-4	T	0-3	9	9
E	12-5	U	0-4	-	11
F	12-6	V	0-5	+	12
G	12-7	W	0-6	/	0-1
H	12-8	X	0-7	=	3-8
I	12-9	Y	0-8	'	4-8
J	11-1	Z	0-9	,	0-3-8
K	11-2	0	0	(	0-4-8
L	11-3	1	1	$	11-3-8
M	11-4	2	2	*	11-4-8
N	11-5	3	3	.	12-3-8
O	11-6	4	4	)	12-4-8

Since the keypunch produces both program cards and data cards, it is necessary to distinguish between the two types. Program cards, also called load cards, are identified by placing a punch in position 12 of the first column of each load card. Data cards are identified by placing a punch in position 12 in the second column of each data card. For long production runs, it is inefficient to make these punches on the individual cards as they are fed through the keypunch. They are therefore made in advance on a large number of cards which are otherwise blank by gang punching.

When a card is identified as a data card, the information which it contains can be entered into the computer only by means of the alphabetic device or the special character device. These devices can accept a maximum of 30 columns of information from each data card. Therefore, although the card has a capacity of 80 columns, only 30 columns are used on each data card. These are columns 11-40 inclusive.

The master card of the keypunch is so programmed that as data cards are punched and a punch has been made in column 40, the card is skipped out, a new card is fed into the keypunch mechanism, and is registered to permit punching to begin in column 11. The requisite punch in column 2 will have previously been gang-punched. Thus, the operator can transcribe text as if on one continuous line without having to attend to the movement of the cards in and out of the keypunch mechanism. On the other hand, the initiation, termination, or rejection of any card is at all times under the control of the operator.

1.4.2.6 The Program

The <u>program</u> is the information and the set of instructions which the digital computer must have in order to effect encipherment into English Braille, Grade Two. The individual pieces of information and the individual instructions of which the program is composed are punched into cards identified as load cards on

he keypunch. This information is then entered into the computer by means of the nput device (see section 1.4.2.11). This must be done before any data informa-ion is supplied to the computer so that the program will be available to insure roper encipherment.

Once in the computer, the program is permanently stored for the duration of n encipherment run. The load cards themselves may be removed from the input de - ice and used again at a later time for another encipherment run. During the ncipherment process, many of the instructions and pieces of information in the rogram are internally modified by the computer so that, at the end of an enci-herment run, many of the program items in the computer will be different from he corresponding items on the load cards.

The correctness of the encipherment into English Braille, Grade Two, de-ends primarily upon the care and the detail built into the program. Thus, the riting of the program is the means by which the skill possessed by a human ranscriber is transferred to a digital computer.

.4.2.7 The Transcription

The <u>transcription</u> is the data information produced by the keypunch under he control of the operator. In the present investigation, it is the set of unched data cards, in their proper order, which have been stacked in the key-unch machine. In a parallel system, it might be a punched paper tape, or a agnetic tape.

.4.2.8 The Verification Operator

The function of the <u>verification operator</u> is to "retranscribe" the text hich is to be enciphered into braille for the purpose of error detection. Ac-ordingly, the verification operator will hereafter be referred to as the <u>roofreader</u>. Like the keypunch operator, the proofreader's "retranscription" is ubject to the editor's instructions, and precisely the same training is re-uired for the proofreader as for the operator.

The "retranscription" does not consist in the production of a duplicate set f data cards. Instead, the transcription is put into a machine called a <u>erifier</u> in the same way that blank cards are put into the keypunch. The proof-eader simulates card punching by operating the keyboard of the verifier as hough it were a keypunch machine. No punching is produced, however. The de-ice merely "compares" the punch pattern already present in a card column with the ensing pattern set up by the proofreader. As long as there is agreement be-ween these two patterns, verification is permitted to proceed. But if there is discrepancy between the two patterns, the verifier mechanism locks and the roofreader must then make a decision. If the proofreader decides that the ensing pattern is incorrect, the device is merely unlocked and verification is ermitted to continue. If, however, the proofreader decides that the punch attern is incorrect, the card must be repunched and the proper correction made, fter which the card must be reverified.

One of the rules of transcription which must be observed both by the opera-r and the proofreader is that each paragraph of prose or line of poetry must egin on a new card. If, therefore, an error occurs of a type in which either o many or too few characters have been punched, thereby causing the displacement

of all characters beyond the point of error, the correction can be made by confining the necessary repunching to the paragraph or line of poetry where the error was made. If the correction results in the deletion or the insertion of one or more cards, this is of no consequence.

1.4.2.9 The Verifier

The verifier is the device for comparing the original transcription with the "retranscription" described above. It is similar in construction and operation to the keypunch; and for each character key on the keypunch, there is a corresponding key on the verifier.

When a card has been verified, the verifier places a notch in the right end of the card before allowing it to be stacked. When a large number of verified cards have been stacked, these notches line up to form a "channel" along the right face of such a stack. It is this "channel" which distinguishes a stack of cards as having been verified by its presence, or of not having been verified by its absence. If this channel is "blocked" by one or more unnotched cards, such cards are quickly identified as not having been verified.

1.4.2.10 The Input Transcription

It was indicated in section 1.4.2 that the digital computer is the heart of the larger system being described. It is, therefore, from the point of view of the digital computer that we speak of <u>input</u> or <u>output</u>.

The verified transcription is called the <u>input transcription</u> because it is the information from this stack of data cards which is fed into the computer for encipherment.

Since each data card has a capacity of 30 character punches, and since each line of print contains approximately 60 to 65 signs, about two data cards are required for the transcription of a line of print.

1.4.2.11 The Input Device

The input device is also called the <u>input reader</u>. It is a device which "reads" the input transcription, one card at a time, and transmits the information contained in the punch patterns to the computer electronically. In this investigation, the input reader is the IBM 533.

Initially, the input transcription is placed into a <u>read hopper</u>. As the computer enciphers the transcription, the input reader will, upon command from the computer, remove a card from the read hopper, transmit its information to the computer, and stack the card in the <u>read stacker</u>. The cards of the input transcription are in no way deformed or disarranged in this process, and are available for rerunning as frequently as desired.

The read hopper and read stacker have a capacity of 2,000 cards each. When the read stacker is full, a switch is automatically thrown to halt the operation of the computer. Similarly, when the read hopper is empty, the operation of the computer is also halted. An attendant is required to refill the read hopper and to remove the cards already read from the read stacker.

Estimating about two data cards per line of print and 45 lines of print per age, the read hopper holds text equivalent to about 20 pages of print when full.

.4.2.12 The Alphabetic and Special Character Devices

When a card has been identified by the input card reader as a data card, he information from that card is not transferred directly to the computer. nstead, it is fed to the alphabetic and special character devices where it is rocessed in the manner described below before transfer to the computer.

The alphabetic and special character devices transform each punch pattern nto a two-digit machine equivalent. In this way, the 30 punch patterns are ransformed into 60 consecutive digits. These are divided into six ten-digit ords in such a way that digits 1-10 constitute the first word, digits 11-20 onstitute the second word, etc. Each of the six words is finally transferred o six consecutively numbered memory locations within the computer. Each memory ocation has the capacity for ten digits. The six consecutive memory locations re called the input area. Below is a table of the 48 characters of which the eypunch is capable together with their machine equivalents.

TABLE 12
MACHINE EQUIVALENTS

haracter	Machine Equivalent	Character	Machine Equivalent	Character	Machine Equivalent
PAOE	00	E	65	U	84
[illegible]	18	F	66	V	85
[illegible]	19	G	67	W	86
[illegible]	20	H	68	X	87
[illegible]	28	I	69	Y	88
[illegible]	29	J	71	Z	89
[illegible]	30	K	72	0	90
[illegible]	31	L	73	1	91
[illegible]	38	M	74	2	92
[illegible]	39	N	75	3	93
=	48	O	76	4	94
[illegible]	49	P	77	5	95
[illegible]	61	Q	78	6	96
[illegible]	62	R	79	7	97
[illegible]	63	S	82	8	98
[illegible]	64	T	83	9	99

.4.2.13 The Digital Computer

A digital computer is a device for carrying out sequences of instructions, alled a program, automatically and at a high rate of speed. In this investigation, the digital computer that was used is the IBM 650.

Although this computer is capable of both exterior and interior modification by the addition of supplementary devices, only the basic computer together ith the alphabetic and special character devices were used. The action of these levices was described in section 1.4.2.12. Although these devices have the addi-

onal capability of converting numeric information in the computer into alpha-
tic, numeric, and special character punch patterns on the output cards, this
pability is not utilized in this investigation.

The two principal features of a digital computer are the following:

(1) The ability to store large amounts of data indefinitely and to "recall"
y part thereof as may be required by the program.

(2) The ability to select alternative sequences of procedures in accordance
th the detection of a condition anticipated in the program; that is, the abil-
y to "make decisions."

The digital computer, under the control of the program, accepts information
om the input transcription and by an elaborate decision-making network, con-
rts it into information which is in correspondence with the English Braille,
ade Two, output. Only numeric information is acceptable to the computer and
e input information is made numeric by the action of the alphabetic and special
aracter devices as described in section 1.4.2.12. The information is kept
meric throughout the entire encipherment procedure. The final result is the
velopment of a sequence of digits which correspond to the required braille
aracters. This numeric information is assembled in the output area. When
is area is full, it delivers its information electronically to an output card
d is then ready to assemble additional output information.

.4.2.14 Numeric Output

As described in the previous section, the numeric information which corresponds
the characters of English Braille is assembled in the output area. The output
ea consists of ten consecutive locations, each with a capacity of ten digits.
f these locations, only the first eight are used in this investigation.

The first location is used for card identification. Of the ten digits in
his location, the left most four, that is, positions 10-7 constitute the number
ssigned to the previously punched card. The digits in positions 5-2 constitute
he number assigned to the card the information for which is currently being as-
embled in the output area. It should be noted that positions 6 and 1 are 0, so
hat a card identification number is a four-digit number.

The last representation on each output card is the end-of-card control (see
ection 1.4.2.17). The representation for this control requires two digits and,
or a full output area, these digits occupy the last positions (positions 2-1)
f the eighth location.

There then remain 68 positions -- ten each in locations 2-7 and eight in
ocation 8 -- for representing braille characters. Since each braille character
equires two digits for its representation, each output card has a capacity of
4 such representations. Since a braille line has a usual length of 36 cells
not all of which are always used), an output card is equivalent to one line
f braille.

In representing a braille character by means of two digits, the first digit
pecifies the dot pattern for the left side of the cell, while the second digit

pecifies the dot pattern for the right side of the cell. Since each side of he cell has exactly three dot positions which may be used all together, in airs, singly, or not at all, there are exactly eight dot combinations possible 'or each side of the cell. In order to assign numbers to these dot combinations, he letters A, B, and C will designate, respectively, the top, middle, and bottom ot position, and in this way no commitment is made as to whether the left or he right half of the cell is being considered. Numbers are then assigned to he dot combinations specified by these letters as shown below:

TABLE 13
DOT COMBINATIONS AND THEIR NUMERICAL EQUIVALENTS

A	1
A-B	2
A-B-C	3
B	4
A-C	5
B-C	6
C	7
No dots	8

By the use of this principle, it is then possible to assign a two-digit umber to each of the 64 braille characters. In the table below, the braille haracters are arranged in accordance with the seven lines of braille (see secion 1.1.2). The corresponding numerical braille equivalent is shown opposite ach braille character.

TABLE 14
NUMBERICAL BRAILLE EQUIVALENTS OF THE BRAILLE CHARACTERS

18	28	11	12	14	21	22	24	41	42
58	38	51	52	54	31	32	34	61	62
57	37	55	53	56	35	33	36	65	63
17	27	15	13	16	25	23	26	45	43
48	68	44	46	47	64	66	67	75	76
71	75	73	72	78	77				

TABLE 14 (continued)
NUMERICAL BRAILLE EQUIVALENTS OF THE BRAILLE CHARACTERS

81	82	83	84	85	86	87	88

The reason for devising this type of numeric output will be developed in he following statements. After punching the output cards it may, under certain ircumstances, be desirable to proofread part or all of it before permitting it o actuate a stereograph machine. However, proofreading by merely looking at he punches is extremely tedious and unreliable. Since this is also the case or any extended output, output cards can either be "interpreted" or "listed". he <u>interpreter</u> is a device which reads the output cards and prints numbers n them in accordance with the punches which are present. A <u>tabulator</u> is a evice which also reads the cards, but prints the information corresponding o one card on a single line of paper. The information from successive cards s printed line after line on sheets of fanfolded paper. However, proofreading raille output by reading long lists of numbers is also tedious and unsatisfac-ory.

It was conceived in this investigation that by replacing the symbols from to 8 on the type wheels or the type bars by the dot combinations which they epresent, facsimile braille could be produced. The editor or any person with knowledge of braille could then sight-read the cards after they were inter-reted or the listing of the cards after they have been tabulated. The proof-eading task would thus become an altogether natural one. Several inquiries nto the possibility of making such type replacements revealed that the cost ould not be justified for the purpose of this investigation.

In addition to the 64 representations of the braille characters, there re four representations for controlling the card reader and the stereograph achine. They are shown below.

TABLE 15
NUMERICAL REPRESENTATIONS FOR CONTROLLING THE OUTPUT EQUIPMENT

end-of-card	91
end-of-line	93
end-of-odd-numbered-page	95
end-of-even-numbered-page	97

The details concerning these controls will be presented in sections 1.4.2.17 nd 1.4.2.18.

.4.2.15 The Output Device

The <u>output device</u> is a device which "writes" information which it receives lectronically from the computer on some medium. In this investigation, the

utput device is the IBM 533, and punches the information it receives from he computer, one card at a time. Thus, the output transcription is again a et of punched cards arranged in their proper order.

During the operation of the computer, the card punch will, upon command rom the computer, remove a blank card from the punch hopper, place it in the unching mechanism, all the information from the computer to be punched into he card will be punched, and the card will be stacked in the punch stacker. he cards punched in this way remain in their proper order when removed from he punch stacker.

The punch hopper and punch stacker each have a capacity of 2,000 cards. full punch stacker or an empty punch hopper will cause the computer to uspend encipherment pending the emptying of the stacker or the reloading of he hopper by an attendant.

Since a card of the output transcription has a capacity for the equiva- ent of 34 braille symbols, each card is approximately equivalent to one line f braille. Since each braille page holds 25 lines, a full punch stacker s equivalent to approximately 80 pages of braille.

.4.2.16 The Output Transcription

The medium which contains the information delivered by the computer as he result of encipherment is called the output transcription. In this inves- igation, the output transcription is a set of punched cards in their proper rder. In a parallel system, the output transcription may be either a punched ape or a magnetic tape.

Two columns are required for the equivalent of each braille symbol. The irst ten columns of each card are reserved for identification purposes. The ast two columns are reserved for the control symbol for end-of-card. The re- aining 68 columns are available for receiving enciphered information and thus ave a capacity for the equivalent of 34 braille symbols.

In addition to the codes for the braille symbols, the output cards also ontain, as a result of encipherment, codes which control the operation either f the output reader (section 1.4.2.17) or the stereograph machine (section .4.2.18).

An output card is distinguished from either a load card or a data card by he presence of a punch in position 12 of column 3.

.4.2.17 The Output Reader

The output reader "reads" the output transcription and uses the information o control either the stereograph machine or itself. In section 1.2.4, both card reader and a tape reader were described, but it is the card reader to hich the present investigation has reference.

Unlike the procedure described in section 1.2.4, the cards are prepared utomatically by the digital computer rather than by a stereograph operator killed in the transcription of English Braille, Grade Two.

The end-of-card control causes the card which is currently in the output ard reader to be fed out of the reading mechanism and to be stacked, and a ew card to be fed into the reading mechanism from the hopper. Actuation of he stereograph machine continues in accordance with the first significant olumn on the newly fed card.

When an output card is fed into the card reader, the card reader "compares" number previously stored therein with the number in positions 10-6 of the ncoming card. If the two numbers are equal, the number in positions 5-1 s stored in the card reader (which has a capacity of one word) and stereo- raph operation is permitted to continue. If the numbers which are compared re not equal, the stereograph operation is halted under the presumption that he cards are out of order.

It will be noted from section 1.4.2.14 that four rather than five digits re used for card identification. This arrangement permits the interpolation f up to nine cards between two original output cards if this is required for aking a correction, and will still permit the sequence of card identification umbers to remain in strictly ascending order.

The stereograph machine attendant must remove the cards from the stacker hen full, and must reload the hopper when empty.

.4.2.18 The Stereograph Machine

The stereograph machine was described in section 1.2.3.

The end-of-line control causes the carriage of the stereograph machine to e returned to the beginning of the line followed by a movement of the plate so s to bring it into position for the embossing of the next braille line. This peration is completely automatic.

There are two end-of-page controls. Both cause the carriage of the stereo- raph machine to be returned to the beginning of the line. However, the action f moving the plate to the next line is omitted. When the control calls for nd-of-odd-numbered-page, the attendant at the stereograph machine must turn the late over. When the control calls for end-of-even-numbered-page, the attendant ust remove the completed plate and replace it by another. The attendant must bey these controls faithfully, otherwise page skipping will be incorrectly im- lemented.

.4.2.19 The Braille Press

This device was described in section 1.2.3. The braille press accepts the lates produced by the stereograph machine and produces the braille text in ultiple copies.

.4.2.20 The Braille Text

The final result of the entire system is the production of the braille text.

It is clear from the descriptions contained in the various subsections of ection 1.4.2 that no skill in the direct transcription into English Braille, rade Two is required of any person. This skill has been transferred to a

gital computer. It is also clear that the operator and the proofreader must lergo a certain amount of training and that they must observe certain rules, ie of which involve the use or the avoidance of contractions.

1.3 Objectives of the Investigation

As has been stated earlier, the principal result of this investigation is formulation of a program under whose control the digital computer is enabled encipher English Braille, Grade Two. This program has been formulated with following objectives:

(1) To create an output, by means of automatic encipherment, which is in ll accordance with the rules of English Braille, Grade Two whenever the inted text is in English and restricted as in section 1.4.2.1.

(2) To require as little specialized knowledge as possible on the part of keypunch operator and the proofreader.

(3) To utilize as little of the storage space in the digital computer as ssible. When a large amount of storage is required, the computer which must used is likely to be a large and less available machine.

(4) To require as little running time as possible. This factor is imrtant when economy of braille production is considered, inasmuch as computer ne is generally rented on an hourly basis.

(5) To be based on such principles as are easily applicable to programs r machines other than the IBM 650. As newer machines become available and IBM 650 becomes obsolete, it is important to be able to translate the prom with ease into the language of the newer machines.

(6) To be so constructed as to be easily modified by changes in the rules braille, and even to point the way to needed changes in these rules.

1.4 Previous Results

Work of a similar nature and with similar objectives has been reported, d such work is now cited:

(1) An attempt to effect automatic encipherment was made by J. Cleave, e results of which appear in INFORMATION THEORY, edited by C. Cherry and blished by Butterworths, London, 1956. The rules of English Braille, Grade o which he attempted to implement are somewhat different from those set forth E.B. In particular the rules which govern the use of contractions which overp prefixes and roots or stems of words were quite different from those in fect today. They were considerably more vague, ambiguous, and less amenable computer processing. A dictionary technique was accordingly used to handle e ambiguous cases, but the length of such a dictionary became prohibitive th respect to the available storage, and the resulting transcription was erefore imperfect and not acceptable for the production of braille texts in antity.

(2) The development of a program for the same purpose was announced in 58 by the Mathematics and Applications Division of IBM. This program was

itten for the IBM 704, a digital computer much larger and faster than the M 650. The program itself has not yet been made available, although a preminary has been published. This report sets forth the main principles used the encipherment, but gives no results as to the degree of accuracy of the tput transcription.

(3) There is currently in progress in the same direction in England a milar investigation by the Royal National Institute for the Blind, but no port either as to equipment used or results obtained is available.

2. THE TECHNIQUE OF ENCIPHERMENT

In the previous section, a detailed description was given of how text ma-
rial requiring encipherment must be prepared for acceptance by the computer, and
w the information so prepared is actually converted into numeric information
d entered into the input area by the alphabetic and special character devices.
description was also given of the numeric output generated in the computer and
sembled in the output area, and how this output is transformed into palpable
aille. It remains to describe the internal process by which the numeric in-
rmation in the input area is transformed into the numeric output which is as-
mbled in the output area. It is the purpose of the following sections to pro-
de this description.

1 Flow of Information

The information in the input area must be disassembled, reassembled, and
ansformed in several stages in order to achieve the final numeric output. The
rious stages of assembly are described in the following subsections. The tech-
que for actually making the transition from each stage to the next will be de-
ribed in section 2.2.

1.1 The Input Area

Six locations are reserved within the computer for the input area. These
cations have a capacity of 30 two-digit equivalents for the input characters.
e input area receives its information directly from the alphabetic and special
haracter devices. Under the control of the program, this information is delivered
e card at a time to the input area.

The equivalents of the input characters are detached, one at a time, from
e input area, examined, and adjoined to the unit of context area, described in
e next section. When there remain no more equivalents of the input characters
detach from the input area, the information from the next card is, upon com-
nd from the computer, entered into the input area. Any information previously
tored in the input area is thereupon lost.

1.2 The Unit of Context

In order to effect correct encipherment, and in order to assemble the final
tput in a manner which is in accordance with the format requirements, it is
cessary to divide the incoming text material into segments, each of which is
lled a <u>unit of context</u>.

Within each paragraph or line of poetry, the unit of context is taken to be
sequence of representations the last one of which is a space but which, except
t the beginning of a paragraph, does not begin with a space. According to this
onvention for the unit of context, the following situations should be noted:

(1) The two spaces which are required at the beginning of each paragraph con-
titute a unit of context by themselves. A line of poetry begins at the left
argin and so is not preceded by any spaces. No unit of context except the one
hich contains the two spaces at the beginning of a paragraph begins with a space.

(2) The space between two consecutive words is associated in the unit of con-xt with the word which precedes it, and not with the word which follows it.

(3) The two spaces between consecutive sentences within the same paragraph line of poetry are associated with the last word of the sentence which precedes em, and not with the first word of the sentence which follows them.

(4) In addition to these types, the unit of context may consist of a single tter, an abbreviation, two words joined by the short dash, a number containing e or more digits, a combination of letters and numbers, and other combinations ich may constitute a unit of context in accordance with the definition given ove. Each of these may be associated with punctuation marks, composition gns, or signs of arithmetic within the same unit of context.

(5) The unit of context may also be one of the nine format controls described section 1.4.2.3.1.3. Since at least one space must precede and follow each these format controls, such units of context cannot contain representations her than those which are pertinent to the controls themselves.

Nine consecutive locations within the computer are reserved for the unit of ntext. Since each location has a capacity of ten digits, and since two digits e required for each simple representation, a capacity of 45 simple representa-ons within the unit of context is available. While it is possible to contrive situation in which a unit of context will exceed this length, a capacity of 45 presentations is considered adequate for any realistic unit of context that ght arise. These nine locations will hereafter be referred to as the <u>unit of ntext area</u>.

To assemble the unit of context, the machine equivalents are detached, one a time, from the input area and examined. The machine equivalent 00 which is signed by the alphabetic device to the punch pattern consisting of a blank lumn and which corresponds to the space is transformed into the representation . This transformation makes it easier to distinguish between consecutive zeros nerated within the computer as the result of a shift instruction or of storing wer than ten digits in one location, and the representation for the space.

The representations for the cent sign, the degree sign, and the percent gn, when encountered, are not adjoined to the unit of context in their natural der. Instead, they are held aside in a location reserved for this purpose so at, at the right juncture according to the rules of English Braille, these ansposable signs of arithmetic may, in their enciphered forms, precede the ex-ession which they affect. (See E.B., section 31).

1.3 The Enciphered Word and Buffered Information

After assembling the unit of context in the unit of context area, the repre-ntations therein are examined, one at a time. Based on the information already tained from the examination of previous representations, one of the following tions is taken:

(1) The entire unit of context is recognized as format control. Thereupon, e information in the format control is analyzed and stored in the appropriate rmat control location, after which immediate action is taken for its imple-ntation if required by the control; otherwise the analyzed format control is lowed to remain in the appropriate storage location for implementation at a

ter appropriate time.

(2) The representation is enciphered and the braille equivalent is adjoined rectly to the enciphered word. Ex.:

The preceding representation was the left parenthesis; the current repre- ntation is the italic sign. The braille equivalent of the italic sign is then ljoined directly to the enciphered word where it follows the braille equivalent the left parenthesis.

(3) The representation is enciphered, but before adjoining it to the enci- ered word, the braille equivalent of the letter sign is first adjoined. Ex.:

The preceding representation was the paragraph sign; the current representa- on is the capital sign. The braille equivalent of the letter sign is adjoined the enciphered word where it follows the braille equivalent of the paragraph gn, after which the braille equivalent of the capital sign is adjoined to the ciphered word where it follows the braille equivalent of the letter sign. (See .B., section 31, last example).

(4) The representation is enciphered, but pending the acquisition of addi- onal information, the braille equivalent is adjoined as buffered information the <u>buffered information area</u>. Ex.:

The first representation in the unit of context was the italic sign, and ts braille equivalent has already been adjoined to the enciphered word. The econd and current character is the capital sign. Its braille equivalent is ad- oined as buffered information. There is as yet insufficient information for de- ermining whether the braille equivalent of the letter sign must appear between he braille equivalents of the italic sign and the capital sign.

(5) The representation is enciphered but pending the acquisition of addi- tonal information, the braille equivalent of the number sign is adjoined as affered information followed by the adjunction of the braille equivalent of the urrent representation as buffered information. Ex.:

The first and current representation in the unit of context is the digit . First the braille equivalent of the number sign is adjoined as buffered nformation, followed by the adjunction of the braille equivalent of the digit as buffered information. There is as yet insufficient information for deter- ining whether the braille equivalent of a transposable abbreviation will be equired to precede the braille equivalent of the number sign. (See E.B., sec- ion 31, examples).

(6) The representation is enciphered and, because of the information which thus made available, the braille equivalents which have been kept as buffered nformation are adjoined to the enciphered word followed by the adjunction of he braille equivalent of the current representation to the enciphered word. x.:

The first representation of the unit of context was the capital sign whose raille equivalent has been adjoined as buffered information. The second repre- entation in the unit of context was the letter i and its braille equivalent was lso adjoined as buffered information where it follows the braille equivalent f the capital sign. The third and current representation is the comma. Because f the information now available, the braille equivalents in the buffered informa- ion location are adjoined to the enciphered word, after which the braille equiva-

t of the comma is adjoined to the enciphered word where it follows the prev-sly described braille equivalents.

(7) The representation is enciphered, the braille equivalent of the number n is adjoined as buffered information followed by the adjunction of the ille equivalent of the current representation as buffered information. How-r, before examining the next representation in the unit of context, the ation which is reserved for the three transposable signs of arithmetic is mined to determine whether one of these signs has occurred as part of the t of context. If so, it is enciphered and its braille equivalent is adjoined the enciphered word. Ex.:

The first representation in the unit of context was the opening parenthesis, its braille equivalent has been adjoined to the enciphered word. The second current representation is the digit 2. The braille equivalent of the number n is adjoined as buffered information after which the braille equivalent of digit 2 is adjoined as buffered information where it follows the braille ivalent of the number sign. Before examining the next representation in the t of context, the location reserved for transposable signs of arithmetic is mined and found to contain the representation of the percent sign. This resentation is enciphered and its braille equivalent is adjoined to the en-hered word where it follows the braille equivalent of the opening parenthesis. this stage, the braille equivalents of the number sign and of the digit 2 are ll buffered information.

(8) The representation is enciphered and its braille equivalent is adjoined buffered information. However, before examining the next representation in unit of context, the location which is reserved for the three transposable ns of arithmetic is examined to determine whether one of these signs has urred as part of the unit of context. If so, it is enciphered and its braille ivalent is adjoined to the enciphered word. The braille equivalent of the ter sign is then adjoined to the enciphered word after which the braille ivalents which are buffered information are transferred to the enciphered d. Ex.:

The first and current character of the unit of context is the representa-n for the letter x. This representation is enciphered and its braille equiva-t is adjoined as buffered information. Before examining the next representa-n in the unit of context, the location reserved for transposable signs of thmetic is examined and found to contain the representation for the dollar n. This representation is enciphered and its braille equivalent is adjoined the enciphered word. The braille equivalent of the letter sign is then ad-ned to the enciphered word where it follows the braille equivalent of the lar sign. The braille equivalent of the x which is buffered information then adjoined to the enciphered word where it follows the braille equivalent the letter sign.

(9) The representation is enciphered but its braille equivalent is kept red until the braille equivalents in the enciphered word have been adjoined the braille line, described in the next section. Ex.:

The unit of context contains a word followed by the short dash. The word already been enciphered and its braille equivalents have already been ad-ned to the enciphered word. The short dash has also been enciphered, but braille equivalents of the enciphered word are adjoined to the braille line. braille equivalent of the short dash is then adjoined to the enciphered word

of which it is now the first braille equivalent. Thus, if there is room on the braille line for the word only but not for the short dash which follows, the word will end one braille line while the short dash will begin the next.

(10) The representation is enciphered, is found to be the space or two spaces, and the braille equivalents of the enciphered word are adjoined to the braille line. Ex.:

The unit of context contains a word. The word has already been enciphered and its braille equivalents are in the enciphered word. The current representation is the space. The enciphered word is adjoined to the braille line. Then, if there is room on the braille line, the braille equivalent of the space is adjoined to the braille line.

Nine consecutive locations are reserved within the computer for the enciphered word. Since each location has a capacity of ten digits, and since each braille equivalent is expressible by two digits, the enciphered word has a capacity of 45 braille equivalents. Since the length of the enciphered word is of the same order as the length of the unit of context, this capacity is adequate for any realistic situation.

Similarly, nine consecutive locations are reserved within the computer for storing buffered information. Therefore, as many as 45 braille equivalents can be stored as buffered information. This capacity is likewise adequate for any realistic situation.

The braille equivalents which are adjoined either to the enciphered word or as buffered information are those listed in section 1.4.2.14, Table 14.

Under certain conditions it is possible to interrupt the process of enciphering the unit of context to adjoin the information already enciphered to the braille line (see item 9) above). In this way, hyphenated words or words joined by the short dash may, if necessary, be adjoined to the end of one braille line and continued on the next, the transition being made at the proper point. The encipherment technique also provides for the division of words into syllables in many cases, and the hyphen is accordingly supplied after a syllable if it must be adjoined to the end of the braille line while the remaining syllables must be adjoined to the beginning of the next braille line.

2.1.4 The Braille Line

After each unit of context or part thereof has been transformed into the enciphered word in the manner outlined in the preceding section, the result of this transformation is adjoined to the <u>braille line</u>.

Nine consecutive locations are reserved in the computer for the braille line. These have a capacity of 45 braille equivalents. Before adjoining the enciphered word to the braille line, a test is made to determine whether there are enough cells remaining on the braille line to allow the adjunction without exceeding the margin requirements specified by the editor. If the braille line is to be either the top or the bottom line of the braille page, this determination must take into account the cells required at the end of the braille line

'or the page number, if any. If there are enough cells, the enciphered word is djoined to the braille line. Encipherment then continues by examining the dditional information in the current unit of context, if any; otherwise, the ext unit of context must be developed and the information therein must be xamined. If, however, the test shows that the enciphered word cannot be ccommodated on the current braille line, several additional tests and procedures re required before the enciphered word can be adjoined to the next braille ine. The most important of these are the following:

(1) A test must be made to determine whether the braille line just assembled as the first or the last braille line of the current braille page. If so, and f a page number is required, this page number must be adjoined to the braille ine. Furthermore, the end-of-line control equivalent must then be adjoined 'or any but the last braille line of the braille page. In the case of the last raille line, one of the end-of-page control equivalents must be adjoined, the hoice depending upon whether the braille page just completed is an odd-numbered r an even-numbered page.

(2) If one of the end-of-page control equivalents has been adjoined to the raille line, the editor's instructions concerning the permanent heading and the age numbering must be carried out at the top of the next braille page before djoining any additional enciphered words to the next braille line. Similarly, fter the braille line before the last one on the braille page has been assembled, he editor's instructions concerning the permanent heading and page numbers ust be carried out on the bottom line of the braille page before terminating he braille page.

(3) At the top of each braille page, a test must be made to determine whether ine control or page control are effective and, if so, whether they require the kipping of a specified number of lines or pages. If such skipping is required, he proper control equivalents must be adjoined to the braille line before adjoin- ng any additional enciphered word to the braille line.

(4) At the end of each braille line, a test must be made to determine whether he centering control is effective. If so, a further test must be made to deter- ine whether the braille line just assembled may be centered on the current raille page or whether, owing to the lack of a sufficient number of additional ines, the current braille page must be terminated and the braille line just ssembled centered at the beginning of the next braille page. When centering s actually undertaken, the number of spaces to be indented to effect correct entering is calculated, and the braille equivalents of this number of spaces re adjoined to the output area, described in the next section, before adjoining he braille line to the output area.

(5) At the end of each braille line, a further test must be made to deter- ine whether outlying control is effective. If so, still further testing is 'equired to determine whether poetry format or right adjustment of the braille ine is required. If poetry format is called for, but the braille line just ssembled is also the beginning of the line of poetry, no indentation is made; ut if the braille line just assembled is a continuation of a line of poetry, he braille equivalents of the proper number of spaces to assure the specified ndentation are adjoined to the output area before adjoining the braille line o the output area. If right adjustment of the braille line is called for, he number of braille equivalents on the line just assembled is subtracted 'rom the number of cells permitted by the editor on the braille line. The umber determined in this way is the number of braille equivalents which are

joined to the output area before adjoining the braille line to the output area.

As described in the foregoing items, any one of three control equivalents be adjoined to the braille line in addition to the braille equivalents themves. All the information which is adjoined to the braille line will be led generically braille equivalents, even if they are control equivalents.

.5 The Output Area

Eight consecutive locations are reserved in the computer as the output area. these, only locations 2-8 receive the braille equivalents from the braille ie. Location 1 is used for purposes of card identification.

After the information on a complete braille line has been assembled, inding the end-of-line control equivalent or one of the end-of-page control iivalents, the information is transferred to the output area, one braille iivalent at a time. As the transfer proceeds, a count is maintained of the aber of braille equivalents which have been transferred to the output area. n 34 braille equivalents have been transferred, the end-of-card control iivalent is adjoined as the last equivalent of the output area. Upon command m the computer, the information from the output area is punched onto an tput card. The identification numbers in location 1 are increased. The nsfer of the braille equivalents from the braille line to the output area is n resumed.

After the information from the braille line has been completely transferred the output area, the several tests and procedures of the foregoing section st be carried out before undertaking the adjunction of another enciphered word the braille line.

When the end-of-line control equivalent has been adjoined to the braille ie because line or page control required immediate implementation rather than ause there was no more room on the braille line, the braille line is adjoined the outer area as usual, but thereafter the end-of-card control equivalent adjoined to the output area after which the information in the output area punched onto an output card without waiting for the output area to attain full capacity of output information. In this way, the transition to a new ragraph or to a new line of poetry causes one run of output cards to be ternated and a new run to be initiated.

2 Program Techniques for Achieving Encipherment

In this section, a description will be given of the more important program chniques which have been devised for carrying out the various tasks required the process of encipherment.

The IBM 650 digital computer is designed primarily for the purpose of carrying t arithmetical operations. Since such operations play a subordinate role in an vestigation of the kind being described, it is necessary to formulate procedures ich are more pertinent to this investigation by putting together the basic structions of which the computer is capable in the proper manner.

There are two principal tasks in this connection. The first task is that selecting the procedures which will be most useful for the purpose of effectg encipherment and to "program" these procedures in terms of the basic IBM 650

instructions. The second task is to formulate the order in which these procedures are to be carried out, and to provide the means for making the transition from one procedure to the next in terms of the basic IBM 650 instructions. The following sections describe how these tasks are accomplished.

2.2.1 The Transfer of Information

It is apparent from the various subsections of section 2.1 that a considerable amount of the encipherment technique is concerned with the transfer of information from one area in the computer to another, or with the adjunction of a machine equivalent or braille equivalent to a specific area. The following are the information transfers which must be undertaken:

(1) A machine equivalent which has been detached from the input area must be transferred to the unit of context area.

(2) The machine equivalent 17 which corresponds to the space and which replaces 00 must be transferred to the unit of context area.

(3) A representation corresponding to a transposable sign of arithmetic must be transferred from the input area to the location reserved for such representations.

(4) A braille equivalent just enciphered must be transferred to the enciphered word area or to the buffered information area.

(5) The braille equivalent of the letter sign or the number sign must be transferred to the enciphered word area or to the buffered information area.

(6) The braille equivalents in the buffered information area must be transferred to the enciphered word area.

(7) Analyzed format controls must be transferred from the unit of context area to locations reserved for these controls.

(8) The information in the enciphered word area must be transferred to the braille line area.

(9) A specified number of spaces must be transferred to the braille line area.

(10) The control equivalent for end-of-line or one of the control equivalents for end-of-page must be transferred to the braille line area.

(11) The braille equivalent of the page number must be transferred to the braille line area.

(12) The braille equivalent of the permanent heading must be transferred to the braille line area.

(13) The information in the braille line area must be transferred to the output area.

(14) A specified number of spaces must be transferred to the output area.

(15) The control equivalent for end-of-card must be transferred to the output area.

While the basic procedure for the transfer of information is the same in 1 these cases, the location from which information originates or to which it transferred are variable. To have a distinct procedure for transferring ch information for each of the required combinations of origin and destinaon would entail an excessive use of the computer's storage capacity. Therere, it is expedient to employ an overall technique to effect the transfer information from any source to any destination. This technique is best exained by an example.

It is now supposed that the information from the braille line area must be ansferred to the output area. It is further supposed that the output area ready contains eight braille equivalents from the previously transferred aille line. Of these, the first five are in location 2 of the output area d the remaining three are in the location designated as LACOA (location for sembling the characters in the output area). In this location, the three aracters are right adjusted, that is, they occupy positions 6-1 of this cation. Finally, it is supposed that there are 35 braille equivalents in e braille line area, none of which has as yet been transferred to the output ea. The following steps are then taken to effect the transfer of information om the braille line area to the output area.

(1) The contents of three locations are transferred to three other locaons as follows:

a. The contents of LACOA are trancferred to LUIRS (location used for information with recipient status). In the current example, this results in the transfer of the sixth, seventh, and eighth braille equivalents in the output area to LUIRS in their right adjusted position (occupying positions 6-1).

b. The contents of CNCOA (count of the number of characters in the output area) are transferred to CNCRS (count of the number of characters with recipient status). In the current example, this number is 8, since there are eight characters already in the output area.

c. The contents of ARIOA (act to receive information for the output area) are transferred to ADISR (act to distribute information sequentially to the recipient). In the current example, the contents which are transferred constitute an instruction to store information in location 3 of the output area.

In the current example, the output area is the recipient of the transferred nformation. Had the recipient been the enciphered word area instead, the conents of three other locations, namely LACEW (location for assembling the charcters in the enciphered words), CNCEW (count of the number of characters in he enciphered word), and ARIEW (act to receive information for the enciphered ord) would have been transferred respectively to LUIRS, CNCRS, and ADISR.

(2) The contents of two other locations pertinent to the braille line area re transferred as follows:

a. The contents of CNCBL (count of the number of characters on the braille line) are transferred to CNCDS (count of the number of characters with donor status). In this example, this number is 35, since this is the number of untransferred braille equivalents in the braille line.

b. The contents of ASIBL (act to supply information from the braille line)

are transferred to ASISD (act to supply information sequentially from the donor). In the current example, the contents which are transferred constitute an instruction to obtain information from location 1 of the braille line area.

(3) The contents of CNODS are examined to determine whether the number therein is 0. In the current example the number is 35. A nonzero condition signifies that the transfer operation must continue. Had the examination revealed that CNODS contains 0, action would have been taken to terminate the transfer operation.

(4) The number in CNORS is increased by 1 and the number in CNODS is decreased by 1. In the current example, the new contents of CNORS are 9 and the new contents of CNODS is 34.

As successive braille equivalents are transferred, the number in CNORS is increased by 1 and the number in CNODS is decreased by 1. Eventually, the number in CNODS will become 0, at which point the transfer operation is terminated.

(5) Location LUIDS (location used for information with donor status) is examined to determine whether its contents are 0. In the current example, the contents of LUIDS will be 0. This signifies that there are no braille equivalents in LUIDS. Before the transfer operation can continue, LUIDS must be replenished with more braille equivalents from the braille line area.

(6) Since LUIDS is 0, the instruction which is now in ASISD (transferred from ASIBL) is carried out. This causes the following actions to be taken:

a. The contents of location 1 of the braille line area are transferred to LUIDS. Five braille equivalents are transferred in this way.

b. The instruction in ASISD is modified so that when it is carried out the next time, information from location 2 of the braille line area will be transferred to LUIDS.

(7) Location LUIDS is again tested for a nonzero condition. Because of the transfer of braille equivalents from the braille line area to LUIDS which has just taken place, the test this time reveals a nonzero condition, and the transfer operation may proceed.

(8) A braille equivalent is detached from LUIDS by taking the following actions:

a. The leading braille equivalent is detached from LUIDS and transferred to LTCDR (location for transferring the character from the donor to the recipient) where it is stored in the right adjusted position (occupying positions 2-1).

b. The remaining contents of LUIDS are shifted to the left so as to occupy the position vacated by the leading braille equivalent. The contents of LUIDS are thus left adjusted. The void created in positions 2-1 because of this left shift is replaced by 00.

As successive characters are detached from LUIDS, additional pairs of

00 are adjoined on the right. After the fifth braille equivalent has been de-ached, the contents of LUIDS will be 0 again. A test at this point will re-eal that additional information must be transferred to LUIDS from the braille ine area. The instruction in ASISD will be called upon to effect this transfer. Because of the modification of this instruction in item (6) b above, the in-formation which will be transferred to LUIDS will be obtained from location 2 of the braille line area.

(9) Location LUIRS is examined to determine whether there is room for another braille equivalent. In the current example, the result of the examina-tion is in the affirmative, since LUIRS at this point contains three braille equivalents and can therefore accommodate two more.

Had the result of the examination been in the negative, that is, had LUIRS already contained five braille equivalents, the following actions would have been taken:

a. The instruction in ADISR (transferred from ARIOA) transfers the in-formation from LUIRS (consisting of five braille equivalents) to location 3 of the output area.

b. The instruction in ADISR is modified so that when it is carried out the next time, it will transfer information from LUIRS to location 4 of the output area.

c. The information in LTCDR (consisting of a single right adjusted braille equivalent) is transferred to LUIRS, thereby erasing the previous information therein. The single braille equivalent now in LUIRS is also right adjusted.

(10) Since LUIRS can accommodate another braille equivalent, this braille equivalent is adjoined to LUIRS by taking the following actions:

a. The contents of LUIRS are shifted left by two positions, thereby making room for the braille equivalent to be transferred. Since it is known that there is room in LUIRS for the next braille equivalent, this left shift does not discard any information already present.

b. The contents of LTCDR (consisting of a single right adjusted braille equivalent) are adjoined to the braille equivalents already present in LUIRS.

(11) A test is made to determine whether information is being transferred to the output area. In the current example the answer is in the affirmative. Had the answer been in the negative, the transfer operation would have continued by reverting to item (5) above.

(12) Since the test shows that information is being transferred to the output area a further test is made to determine whether the output area already contains 34 braille equivalents. This test is made by examining the number in CNCRS and noting whether or not that number is 34. In the current example, the number in question is 9, and not 34. Therefore, the transfer operation is continued by reverting to item (3) above.

Had the number in CNCRS been 34, the following actions would have been taken.

a. The end-of-card control equivalent is adjoined to LUIRS. Since this control equivalent is the 35th adjunction,, LUIRS must, at this point contain exactly five braille equivalents.

b. The contents of LUIRS are transferred to location 8 (the last location) of the output area.

c. The contents of CNOES (34) is now reset to 0. Furthermore, the contents of LUIRS is also made to be 0.

d. The instruction in ADISR is modified so that when it is used the next time, it will transfer information from LUIRS into location 2 of the output area. Prior to such modification, the instruction in ADISR, if carried out, would have transferred information from LUIRS into location 8 of the output area.

e. The information from the output area is punched into an output card. The information from location 1 of the output area is punched into columns 1-10 of the output card. This information is the card identification numbers. The information in locations 2-8 of the output area is punched into columns 11-80 of the output card.

f. The card identification numbers are increased by 1 for both cards.

g. The transfer operation is continued by reverting to item (5) above. In the current example, as the transfer operation proceeds, when the number in ONORS is 34, the number in ONODS is 9. Therefore, a reversion to item (5) above (testing the number in ONODS) will reveal that the transfer operation must continue. There are still 9 braille equivalents to transfer. When the test shows ONODS to be 0, five of the nine braille equivalents will have been transferred to location 2 of the output area, and the remaining four to LUIRS, where they are right adjusted.

(13) The contents of ADISR, ONORS, and LUIRS are transferred, respec-ively, to ARIOA, ONOOA, and LAOOA, from which they were taken in item (1) above. he information in all three of the locations being transferred will have been odified during the operation of transferring information from the donor to the ecipient.

(14) The information in all of the locations of the braille line area is isposed of by resetting all of these locations to 0. In addition, ONOBL (which t this point still contains 35) is also reset to 0. At this point, the transfer f information from the braille line area to the output area of the example is com-lete.

With some minor modifications, the method of transferring information from ny origin to any destination is the same as just described and illustrated in the bove example. There is one point requiring attention which was implicit in the bove example but which is now elaborated.

In item (13) above, the contents of LUIRS were transferred to LACOA. Had nformation been transferred to the braille line area rather than to the output rea, as in the above example, the information in LUIRS would have been trans-erred to LACBL (location for assembling the characters in the braille line). If UIRS, at the time of transfer, contained fewer than five braille equivalents, these

would have been right adjusted and they would similarly be right adjusted after having been transferred to LACBL. At this point, the braille line area is not ready for the transfer of its information to the output area because some of its braille equivalents (the terminal ones in LACBL) do not occupy any of the locations in the braille line area. Before this transfer of information can be undertaken, the information in LACBL must be left adjusted and then transferred to the first as-yet-unoccupied locations of the braille line area. Instead of left adjusting the contents of LACBL after the transfer from LUIRS, it is equivlaent to carry out the left adjustment on LUIRS before the transfer. The steps in the left adjustment process are as follows:

a. The information in LUIRS is shifted left until the first nonzero digit occupies position 10. The information in this new position is transferred from LUIRS to LACBL (as in the discussion above) or to a corresponding location when an area other than the braille line is the recipient of the transferred information.

b. By means of the number in CNCRS, a calculation is made as to the number of locations in the recipient area to which information has alreadb been transferred, and by means of this number, the instruction in ADISR is initialized. This initialization will cause the instruction in ADISR, when next it is carried out, to transfer the instruction from LUIRS to location 2 of the output area if the output area is the recipient of the transferred information, or to location 1 of any other recipient area.

c. An action similar to that of item (13) above is then carried out, the contents of ADISR, CNCRS, and LUIRS being transferred to corresponding locations pertaining to the recipient area.

2.2.2 The Detection of Conditions Requiring Attention

At many strategic points in the encipherment process, it is necessary to ascertain whether certain conditions are present, and if so, to take the proper action required by the presence of the condition.

The presence of some conditions can be detected by examining the format controls. Among such conditions are the following:

(1) TWBCE (test whether braille control is effective). If so, encipherment must be in English Braille, Grade One. Otherwise, encipherment is in English Braille, Grade Two.

(2) TWCCE (test whether the centering control is effective.. If so, this test is made after assembling the braille line. If the answer is in the affirmative, a calculation is made to determine the number of spaces which must be indented for proper centering. The braille equivalents of this number of spaces is transferred to the output area followed by the transfer to the output area of the braille line.

(3) TWDCE (test whether dot control is effective). This test must be made when the unit of context consists exclusively of machine equivalents which represent numeric characters. If the answer is in the affirmative, the numeric characters are interpreted as designating dot positions in the braille cell.

(4) TWLCE (test whether line control is effective). This test must be made at the beginning of each braille page so that if, at that point, it is required to skip a specified number of lines, this can be done.

(5) TWPCE (test whether page control is effective). This test must be undertaken at the beginning of each braille page so that if, at that point, it is required to skip a specified number of pages, this may be done.

(6) TWOCE (test whether outline control is effective). This test must be made at the end of each braille line to determine whether that braille line must be treated as poetry format and indented accordingly, or whether that line must be right adjusted.

(7) TWPFE (test whether poetry format is effective). This test must be made to distinguish between the two kinds of effectiveness of outline control.

The presence of other conditions can be detected by examining the specifications which the editor has made and which were fed directly into the program. Among such indications are the following:

(8) TWPHR (test whether a permanent heading is required). This test must be made at the top and at the bottom line of each braille page to determine whether the permanent heading supplied by the editor must appear there and, if so, the information in the permanent heading must be transferred to the braille line area before any additional encipherment can be undertaken.

(9) TWPNR (test whether page number is required). This test must be made before termination of the top or the bottom line of each braille page to determine whether the editor has specified that a page number appear in the right-hand corner. The type of page number must be ascertained from the information in the numbering control, and the braille equivalent of this page number must be transferred to the braille line before any other procedures can be undertaken.

The detection of still other conditions is part of the program itself. These conditions are as follows:

(10) TUCAE (test whether the unit of context is available for encipherment). This test must be made after the information in the enciphered word area has been transferred to the braille line area. In certain situations, only part of the unit of context is enciphered and then transferred to the braille line, in which case, additional encipherment is possible from the remainder of the unit of context.

(11) TEWAA (test whether an enciphered word is available for adjunction). This test must be made at the beginning of the braille line. If an enciphered word is available for adjunction, it is because there was no room for its adjunction on the preceding braille line. The information in the enciphered word area must then be transferred to the braille line area before further encipherment can be undertaken.

(12) TROBL (test for room on the current braille line). This test must be made after having enciphered a word. If there is room on the current braille line, the information in the enciphered word will be transferred to the braille line area.

Finally, some types of action must be taken without testing for the presence

of any condition requiring the action, and this action is initiated either by format control or within the program itself. Such actions are the following:

(14) PTNBP (proceed to the next braille page). This action is initiated by line control.

(15) ASNSL (adjoin the specified number of spaces to the line). This action is initiated by space control and causes the braille equivalents of a specified number of spaces to be adjoined to the braille line.

(16) TVSVN (terminate the volume by supplying the volume number). This action is initiated by volume control.

(17) TVLVT (terminate the volume as the last volume of the text). This action is also initiated by the volume control.

(18) CSBPH (compute the spaces before the permanent heading). This action is initiated by the program when it is known that a permanent heading is required. The number of spaces calculated assures correct centering of the permanent heading.

(19) CSAPH (compute the spaces after the permanent heading). This action is taken as soon as it is known that a page number must appear at the end of the braille line which carries a permanent heading. The number of spaces computed is the number of spaces which must intervene between the last braille character of the permanent heading and the first braille character of the page number.

(20) CSBCH (compute the spaces before the centered heading). This action is taken as soon as a centered caption must appear on a braille line. The number of spaces calculated assures correct centering.

(21) ENBPN (encipher the next braille page number). This action is taken at the end of each braille page when braille page numbers are required. The braille page numbers are automatically increased before encipherment so that the braille pages are numbered consecutively. This action is also taken whenever numbering control calls for the next print page or another print page.

2.2.3 The Encipherment of Representations

As mentioned in section 2.1.3, the representations in the unit of context are enciphered into their braille equivalents, one at a time, provided that these representations are not pertinent to format control. In this section, the method for finding the braille equivalent corresponding to a representation will be described.

The encipherment is by means of a table of representations and their corresponding braille equivalents. The encipherment is effected as follows:

(1) The table of representations and corresponding braille equivalents contains 83 entries. Of these, the first 45 entries are concerned with simple representations, and the remaining 38 entries are concerned with compound representations. In the case of compound representations, only those having two components are stored in the table. Compound representations require four positions for their storage. In the table, these are positions 10-7. Simple representations require two digits for their storage. In the table, these are positions 8-7. In the case of simple representations, positions 10-9 contain 00. The

machine equivalents of the representations are stored in numerically ascending order; the simple representations are stored first, followed by the compound representations.

(2) The representations for the ellipsis requiring three machine equivalents, and the representation for the long dash, requiring four machine equivalents, are not stored in the table. These representations must be detected and enciphered before referring to the table.

(3) The double space, the double capital sign, and the two dots are enciphered as compound representations.

(4) When the capital sign is followed by the accent sign, the machine equivalent for this configuration is 484831. In this configuration, the machine equivalent for 48 must be enciphered as the capital sign first, followed by the compound machine equivalent 4831 as the accent sign. If the compound machine equivalent 4848 were enciphered first, followed by the encipherment of the simple machine equivalent 31, the result would be the double capital sign followed by the virgule.

(5) For technical reasons related to the behavior of the IBM 650, two consecutive 9's whose machine equivalent is 9999 are enciphered as a compound representation.

(6) To each of the representations in the table, as well as to the ellipsis and the long dash, there is assigned a classification number. This classification number is used in conjunction with the cumulative information number to be described in section 2.2.4 to determine the proper action which must be taken as the result of having enciphered the current representation. Each classification number is expressed by two digits and is stored in positions 6-5 of the table entries (except for the ellipsis and the long dash which are not stored in the table). The classification numbers and the representations to which they pertain are shown in the following table:

Table 16
TABLE OF CLASSIFICATION NUMBERS

Classification Numbers	Corresponding Representations
10	single space
11	double space
20	paragraph sign, section sign, dollar sign
21	decimal point
22	degree sign, cent sign, percent sign
30	line control
31	page control
32	outline control
33	space control
34	braille control
35	numbering control
36	centering control
37	volume control
38	dot control
40	termination sign, italic sign
41	single capital sign, double capital sign
43	number sign

TABLE 16 (continued)
TABLE OF CLASSIFICATION NUMBERS

Classification Numbers	Corresponding Representations
44	letter sign
45	accent sign
49	left parenthesis, left bracket, left inner quote, left outer quote, asterisk, long dash, ellipsis
50	semicolon, exclamation point, right parenthesis, right bracket, right inner quote, right outer quote, question mark, two dots
51	period
52	virgule
53	comma
54	hyphen
55	colon
56	apostrophe
57	short dash
61	a
62	i
63	b, c, d, e, f, g, h, j
64	o
65	s
66	k, l, m, n, p, q, r, t, u, v, w, x, y, z
70	0, 4, 5, 6, 7, 8, 9, 99
71	1
72	2, 3
73	transposition sign

The reason for classifying these representations in this manner lies in the requirements of the rules of E.B. The manner in which this information is used will be described in section 2.2.4.

(7) The braille equivalents which correspond to the tabulated representation are stored in positions 4-1. If a braille equivalent is expressible in two digits, these are stored in positions 4-3, and positions 2-1 contain 00. The transposition sign has no braille equivalents and positions 4-1 contain the machine equivalents of the format controls. The braille equivalents of the ellipsis and the long dash require six and eight digits, respectively, for their representation, and are stored separately, as are the representations themselves.

The complete table of representations, classifications numbers, and braille equivalents is shown below:

TABLE 17

TABLE OF REPRESENTATIONS, CLASSIFICATION NUMBERS, AND BRAILLE EQUIVALENTS

Representation	Machine Equivalent	Classification Number	Braille Equivalent
space	0017	10	8800
period	0018	51	4600
right parenthesis	0019	50	6600
asterisk	0029	49	7474
virgule	0031	52	7100
comma	0038	53	4800
left parenthesis	0039	49	6600
capital sign	0048	41	8700
hyphen	0049	54	7700
a	0061	61	1800
b	0062	63	2800
c	0063	63	1100
d	0064	63	1200
e	0065	63	1400
f	0066	63	2100
g	0067	63	2200
h	0068	63	2400
i	0069	62	4100
j	0071	63	4200
k	0072	66	5800
l	0073	66	3800
m	0074	66	5100
n	0075	66	5200
o	0076	64	5400
p	0077	66	3100
q	0078	66	3200
r	0079	66	3400
s	0082	65	6100
t	0083	66	6200
u	0084	66	5700
v	0085	66	3700
w	0086	66	4300
x	0087	66	5500
y	0088	66	5300
z	0089	66	5600
0	0090	70	4200
1	0091	71	1800
2	0092	72	2800
3	0093	72	1100
4	0094	70	1200
5	0095	70	1400
6	0096	70	2100
7	0097	70	2200
8	0098	70	2400
9	0099	70	4100

TABLE 17 (continued)
TABLE OF REPRESENTATIONS, CLASSIFICATION NUMBERS, AND BRAILLE EQUIVALENTS

epresentations	Machine Equivalent	Classification Number	Braille Equivalent
ouble space	1717	11	8888
wo dots	1818	50	7878
ecimal point	2018	21	8500
aragraph sign	2019	20	3172
ection sign	2020	20	6178
ollar sign	2028	20	4600
egree sign	2029	22	1222
ent sign	2030	22	1100
ercent sign	2031	22	4431
olon	2818	55	4400
ight outer quote	2819	50	7600
eft bracket	2820	49	8766
xclamation point	2828	50	6400
eft inner quote	2829	49	8767
ight bracket	2830	50	6678
ight inner quote	2831	50	7678
emicolon	2838	50	6800
eft outer quote	2839	49	6700
uestion mark	2848	50	6700
postrophe	2849	56	7800
line control	3018	30	3018
page control	3019	31	3019
outline control	3020	32	3020
space control	3028	33	3028
braille control	3029	34	3029
numbering control	3030	35	3030
centering control	3031	36	3031
volume control	3038	37	3038
dot control	3039	38	3039
termination sign	4818	40	8778
number sign	4828	43	7300
letter sign	4829	44	8600
italic sign	4830	40	8500
accent sign	4831	45	8100
double capital sign	4848	41	8787
transposition sign	4849	73	0000
short dash	4949	57	7777
99	9999	70	4141

(8) The procedure for finding and storing the braille equivalent and the classification number corresponding to a representation is as follows:

a. The leading four machine equivalents in the unit of context are examined to determine whether they constitute the representation for the long dash. If they do not constitute the long dash, the first three machine equivalents in the unit of context are examined to determine whether they constitute the representation for the ellipsis. If there are fewer than four machine equivalents in the unit of context for the first examination, or fewer than three for the second examination, the empty positions will be occupied by zeros. If the machine equivalent for either the long dash or the ellipsis is detected, see f below.

b. The first three machine equivalents in the unit of context are examined todetermine whether they constitute the configuration 484831 which signifies the capital sign followed by the accent sign. If this configuration is detected, see e below.

c. The first two machine equivalents in the unit of context are isolated. If there is only one machine equivalent in the unit of context, the remaining two digits will be 00. The configuration of the two machine equivalents is left adjusted and stored in LHAPO (location holding the argument pending comparison).

d. The argument just stored is compared, in turn, with the successive entries in the table until, for the first time, an entry is found whose numerical content is equal to or exceeds the numerical content of the argument. The table entry found in this way is isolated.

e. The argument stored in LHAPO is compared for an exact match in positions 10-7. If there is an exact match, see f below. If the match is not exact, it is because the configuration in LHAPO is not a representation but a succession of two representations, or it is a single representation in the wrong positions (positions 10-9 instead of 8-7). Therefore, one machine equivalent of the unit of context is isolated, left adjusted so that it occupies positions 8-7, and then stored in LHAPO. In the case of the configuration 484831 discussed in b above, when this configuration is detected, its leading machine equivalent is isolated, positioned so as to occupy positions 8-7, and stored in LHAPO. In either case, the procedure continues as described in d above. This time, an exact match must be found.

f.. When an exact match has been found between the contents in positions 10-7 ofLHAPO and the table entry selected, or when the long dash or the ellipsis have been detected, the classification number and the braille equivalent are isolated. The classification number is stored in the right adjusted position (occupying positions 2-1) into LRNON (location receiving the number classification number). The braille equivalent is stored in LHBER (location holding the braille equivalent of the representation) in the left adjusted position (beginning in position 10).

g. A calculation is made to determine the number of machine equivalents in the representation just enciphered. This number is used in h below when disposing of the number of machine equivalents in the representation just enciphered. Similarly, a calculation is made of the number

of numeric equivalents of the braille equivalent just found. This number is used when adjoining the braille equivalent either to the enciphered word area or to the buffered information area.

h. The representation just enciphered is discarded from the unit of context. This entails the disposition of from one to four machine equivalents. The remaining machine equivalents in the unit of context are shifted left so as to occupy the positions vacated by the discarded machine equivalents. Thus, after the disposition, the leading machine equivalents in the unit of context constitute the next representation requiring encipherment.

,2.4 The Accumulation of Information

The technique to be described in this section is used principally in building up the enciphered word, but it is used in other parts of the program as well.

In building up the enciphered word one character at a time, the action to be aken depends upon the cumulative information number, which contains pertinent nformation concerning the representations already enciphered, and upon the classification number, which contains information pertinent to the representation ust enciphered. Like the classification number, the cumulative information numer also requires two digits. The required action is specified in a table of umulative information and classification numbers. This table is constructed as ollows:

(1) Positions 10-9 of each table entry contain a cumulative information umber. Positions 8-7 of each table entry contain a classification number. The able is arranged in numerically ascending order of these four-digit configurations.

(2) Positions 6-5 of each table entry contain a cumulative information number. This number is for the purpose of updating the previous cumulative information number, based on the classification number of the representation just enciphered.

(3) Positions 4-1 specify the procedures which must be carried out in order to take the proper action.

The procedure which employs the technique being described operates as follows:

(1) The two digits which constitute the cumulative information number and the two digits which constitute the classification number are combined into a four-digit configuration. In this configuration, the cumulative information number comes first, followed by the classification number.

(2) This four-digit configuration is used as an argument for the table of cumulative information and classification numbers. The entries in the table are compared in succession with this argument until, for the first time, a table entry is found whose numeric content is equal to or exceeds the numeric content of the argument.

(3) The information in positions 10-7 of this table entry are discarded, and the cumulative information number in positions 6-5 is isolated.

(4) The isolated cumulative information number is made to replace the previously stored cumulative information number, thus updating the accumulated information.

(5) The information in positions 4-1 is then used to carry out a sequence of procedures designed to meet the current situation.

(6) When these procedures have been carried out, the next representation in the unit of context is enciphered and another classification number thus obtained.

(7) The new cumulative information number and the new classification number are again combined as in item (1) above, and the sequence of steps is repeated.

The following example of the operation of this technique is analyzed in detail below because it is typical of the general procedure used to effect encipherment.

It is supposed that the text material is

25 in.

The operator has punched the following:
2, 5, transposition sign, i, n, period, two spaces
The two spaces were punched because the end of a sentence was reached. These punches have been transformed by the alphabetic and special character devices into machine equivalents which have been entered into the input area. The unit of context which was developed on the basis of this information therefore has the following configuration

92 95 48 49 69 75 18 17 17

Since no encipherment has as yet taken place, the cumulative information number as well as the classification number is 00. The encipherment of this word is now ready to begin.

(1) The cumulative information number and the classification number are combined to form the configuration 0000. This configuration is used as an argument for comparison with the entries in the table of cumulative information and classification numbers. The entry selected contains 0000 in positions 10-7. These digits are described. Positions 6-5 contain the cumulative information number 00. This number is accordingly stored in LHCIN (location holding the cumulative information number). Positions 4-1 of this entry now call for the encipherment of the leading representation in the unit of context.

Encipherment of the leading representation results in a classification number of 72 which is stored in LRNCN (location receiving the new classification number), and a braille equivalent of 28, which is stored in LHBER (location holding the braille equivalent of the representation). The leading representation

the unit of context is then discarded. The revised unit of context now has configuration:

95 48 49 69 75 18 17 17

(2) Again the cumulative information number and the classification number combined to form the configuration 0072. When this configuration is used an argument for comparison with the entries in the table of cumulative information and classification numbers, the entry selected has 0072 in positions -7. These digits are discarded. The selected entry also contains the cumulative information number 72 in positions 6-5. This number is accordingly ored LHCIN. Positions 4-1 of this location then call for the following action be taken.

a. ARSBI (accord recipient status to the buffered information). This is in preparation for the transfer of braille equivalents to the buffered information area.

b. TNSDR (transfer number sign from donor to recipient). The braille equivalent of the number sign is 73.

c. TERDR (transfer the enciphered representation from the donor to the recipient). This causes the braille equivalent of the digit 2 to follow the braille equivalent of the number sign.

d. DBIRS (disengage the buffered information from recipient status). At this point, all the locations in the buffered information area contain 0, but LACBI (location for assembling the characters for the buffered information) has the following configuration:

00 00 00 73 28

e. TTRNC (test for a transposable representation, numeric condition). This test shows that no transposable sign of arithmetic is associated with the current unit of context. The program is thus led to the encipherment of the next representation.

Encipherment of the leading representation of the unit of context this time esults in a classification number of 70, which is stored in LRNON, and the raille equivalent of 14 stored in LHBER. When the representation which has just een discarded is removed from the unit of context, the resulting configuration is:

48 49 69 75 18 17 17

(3) LHCIN and LRNCN are again combined to form the configuration 7270. When this configuration is used as an argument for comparison with the entries in the table of cumulative information and classification numbers, the entry selected contains 7270 in positions 10-7. These digits are discarded. The cumulative information number in positions 6-5 is 70, and this number is stored into LHCIN. The information in positions 4-1 now calls for the following action.

a. ARSBI

b. TERDR

c. DBIRS

As a result of this action, the locations in the buffered information area are still 0, but LACBI now has the following configuration:

00 00 73 28 14

The program is thus led to the encipherment of the next representation. Encipherment of the leading representation of the unit of context results in a classification number of 73 which is stored in LRNCN. However, since the representation is the transposition sign, no braille equivalent results and the configuration 0000 is stored in LHBER.

When the representation for the transposition sign is detached from the unit of context the resulting configuration is

69 75 18 17 17

(4) LHCIN and LRNCN are combined with a resulting configuration of 7073. When this configuration is used as an argument and compared with the entries in the table of cumulative information and classification numbers, the entry selected contains 7073 in positions 10-7. These digits are discarded. Positions 6-5 contain the cumulative information number 72 and this number is stored in LHCIN. The information in positions 4-1 calls for no action at all to be taken. We are thus led to item 5.

(5) LHCIN and LRNCN are again combined, this time forming the configuration 7273. The entry selected also contains 7273 in positions 10-7, and these are discarded. The cumulative information number in positions 6-5 is 73 and this number is stored in LHCIN. The information in positions 4-1 calls for no action other than the encipherment of the next representation.

The next representation is the letter i. Its encipherment causes the classification number 62 to be stored in LRNCN and the braille equivalent 41 to be stored in LHBER. The leading representation is now discarded. The resulting configuration in the unit of context is:

75 18 17 17

(6) LHCIN and LRNCN are combined to form the configuration 7362. The entry selected also contains 7362 in positions 10-7. These are discarded. The cumulative information number in positions 6-5 is 69 and this is stored in LHCIN. Positions 4-1 now call for the following action.

a. SBEEN (save braille equivalent and encipher the next). The braille equivalent 69 which is now in LHBER is transferred to FLPCO (first letter of a possible contractable combination). The program is thus led to the encipherment of the next representation.

The leading representation is now n. Its encipherment results in the classification number 66 which is stored in LRNCN, and the braille equivalent 52 which is stored in LHBER. When the representation which has just been enciphered is discarded, the resulting configuration in the unit of context is

18 17 17

(7) When LHCIN and LRNCN are combined the resulting configuration is 6966. The entry selected also contains 6966 in positions 10-7. These digits are discarded. Positions 6-5 contain the cumulative information number 73, and this number is stored in LHCIN. The information in positions 4-1 now causes the following action to be taken:

a. ACCIN (adjoin contractable combination for <u>in</u>). Before actually adjoining the braille equivalent of the <u>in</u> contraction, two conditions must be satisfied. The braille representation just enciphered must actually be the letter n. The classification number 66 does not single out the letter n, but applies to any letter from a to z with the exception of o and s. The second condition to be satisfied is that braille control must be ineffective, thereby requiring English Braille Grade Two, and not Grade One. In the present example, both of these conditions are satisfied. Therefore the <u>in</u> braille equivalent, 74, is put into LHBER.

b. ARSEW (accord recipient status to the enciphered word).

c. TERDR

d. DEWRS (disengage enciphered word from recipient status). As a result of this action, the locations of the enciphered word are all 0, but LACEW (location for assembling the characters in the enciphered word) contains the following configuration:

00 00 00 00 74

The program is thus led to the encipherment of the next representation.

Encipherment of the next representation, which is the period, leads to the classification number 51 which is stored in LRNCN, and the braille equivalent 46 which is stored in LHBER. When the period is discarded from the unit of context, the resulting configuration is

17 17

(8) When LHCIN and LRNCN are combined, the configuration is 7351. The entry which is selected also contains 7351 in positions 10-7. These digits are discarded. The cumulative information number in positions 6-5 is 60 and this is stored in LHCIN. The information in positions 4-1 then causes the following action to be taken:

a. ARSBI. This is in preparation for left adjusting the information in LACBI and transferring the result to location 1 of the buffered information area.

b. LAFLR (left adjust the final location of the recipient). The information now in LUIRS (transferred from LACBI) is left adjusted.

c. IIDIS (initialize the instruction which distributes information sequentially). The instruction now in ADISR (transferred from ARIBI) is reset to its initial value. In the present case, the action was unnecessary, since the instruction in ARIBI (now in ADISR) was not modified.

d. DBIRS. As the result of this action, the configuration in location 1 of the buffered information area is

73 28 14 00 00

and the other locations are 0.

e. ARSEW. This action is preparatory for the transfer of information from the buffered information area.

f. TBIDR (transfer the buffered information from the donor to the recipient).

g. DEWRS (disengage the enciphered word from recipient status). As a result of this action, the locations in the enciphered word area are 0, but LACEW (location for assembling the characters in the enciphered word) now contain the following configuration:

00 74 73 28 14

h. RBIIC (reset the buffered information to its initial condition). As the result of this action, all the locations in the buffered information area are reset to 0. In addition, ARIBI (set to receive information for the buffered information), CNCBI (count of the number of characters in the buffered information), and LACBI (location for assembling the characters in the buffered information) are all initialised. Thus, the buffered information area is readied to receive the new informatio n as required. The program is thus led to the encipherment of the next representation.

The leading representation is the double space. Its encipherment produces the classification number 11 which is stored in LRNCN, and the braille of 8888 which is stored in LHBER. When the double space is discarded from the unit of context, the unit of context is 0.

(9) The numbers in LHCIN and LRNCN are combined to produce the configuration 6011. The entry selected also contains 6011 in positions 10-7. These digits are discarded. Positions 6-5 contain the cumulative information number 00 and this is stored in LHCIN. The information in positions 4-1 then causes the following action to be taken:

a. ARSEW

b. TPFDR (transfer of the period from donor to recipient). Had the keypunch operator punched only one space instead of two, the corresponding classification number would have been 10 rather than 11, and the braille equivalent of the period would not have been adjoined, even though it was previously enciphered. With a single space, the period is regarded as the abbreviation point only. The braille equivalent of the period is 46.

c. DEWRS. As a result of this action, the locations of the enciphered word are still 0, but LACEW contains the following configuration:

74 73 28 14 46

No encipherment is called for at this point, and the program is thus led to item (10).

(10) The numbers in LACIN and LRNCN are combined to form the configuration 0011. The entry selected also contains 0011 in positions 10-7, and these digits are discarded. Positions 6-5 contain the cumulative information number 00 and this is stored in LACIN. The information in positions 4-1 now causes the following action to be taken:

a. ARSEW. This action is in preparation for left adjusting the contents of LACEW and storing the result in location 1 of the enciphered word area.

b. LAFLR. In the present situation the contents of LUIRS (transferred from LACBI) cannot be left adjusted since this location already contains five braille equivalents. Thus, this action accomplishes nothing.

c. IIDIS. This action initializes the instruction now in ABISR (transferred from ARIEW). In the present case, the instruction is already at its initial value so that this action is also unnecessary.

d. DEWRS. As a result of this action, location 1 of the enciphered word word now contains the following configuration:

74 73 28 14 16

The other locations in the enciphered word area are 0.

e. TEWT2(terminate enciphering of word by table 2). In the program, the table of cumulative and classification numbers is referred to as table 2. This action relinquishes control of the encipherment process and permits the enciphered word to be adjoined to the braille line area if there is room on the same line of braille. The program then proceeds to develop the next unit of context. Control is then returned to the encipherment process for the next word.

2.2.5 The Contraction of Capital Words

When a word is associated with marks of punctuation or signs of composition which precede it, these are enciphered, and their braille equivalents are transferred to the enciphered word area. The letters of the word itself are also enciphered, one letter at a time, but their braille equivalents are assembled in the buffered information area.

The problem of the placement of the letter sign before a single letter or a combination of letters which could be taken for a short form word is completely solved by the methods described in the foregoing sections. Similarly, the problems of the use or the avoidance of the number sign, of transposable signs of arithmetic, or of transposable abbreviations are solved by the same methods. Problems of this kind are called contraction-independent problems since they would have to be solved even if encipherment were entirely into the English Braille, Grade One.

Some of the same methods are used for solving the contraction-dependent problem. As an example, it is supposed that the left quotation mark is followed by the word his. As the result of the information available from the cumulative information number after the letter-by-letter encipherment has been completed, the contraction for his is avoided. This avoidance is correct according to E.B., section 39. In a similar manner, the presence of a hyphen, short dash, or apostrophe before the letter sequence com will prevent the com contraction from being used, according to E.B., section 46. The presence of the italic sign or of the capital sign before the words to, into or by will prevent the contraction of these words if the following word is preceded, respectively, by the italic sign or the capital sign, according to E.B., section 41b.

When the letter-by-letter encipherment of a sequence of letters has been completed, braille control is consulted to determine its effectiveness. If braille control is effective, so that Grade One is required, the braille equivalents in the buffered information area are transferred to the enciphered word area, where they follow any previously enciphered punctuation marks or signs of composition. Thus, the braille word is correctly enciphered in the enciphered word area. If braille control is ineffective, so that Grade Two is required, the methods to be described in the following two subsections are used. In the end, the braille equivalents are again transferred to the enciphered word area where they follow any previously enciphered punctuation marks or signs of composition. If the letter sequence is followed by more punctuation marks or signs of composition, these are enciphered and transferred to the enciphered word area where they follow the braille equivalent of the enciphered word. The methods are those previously described.

2.2.5.1 Word Segmentation

The presence of a contractable letter combination does not automatically entail the use of the corresponding braille contraction. The problem of when to use and when to avoid the use of the contraction is a major one in the overall problem of encipherment into English Braille, Grade Two. The following few examples give a small idea of what is involved.

The ea contraction must not be used in uneasy, but it must be used in seaman and in create. The st contraction must not be used in mistrust, but must be used in sustain. The sh contraction must not be used in mishandle; the the contraction must not be used in sweetheart; the wh contraction must not be used in rawhide. (See E.B., section 34, for a basis of making these decisions).

This problem is solved by the technique of word segmentation. By this process, a word is divided into several parts -- prefixes, stems, roots, and suffixes. The segmentation is achieved by referring to stored tables of prefixes, roots, stems, and suffices. After the segmentation, each segment is enciphered separately, thus avoiding the use of overlapping contractions. A bonus consequence of this technique is the capability, in many cases, to divide a word between braille lines between syllables - a capability entirely absent from the encipherment technique reported by other investigators concerned with the same problem.

2.2.5.1.1 Prefixes

When a word is segmented, the first part of the segmentation process is concerned with the identification of prefixes. This is effected by means of a stored table of prefixes. No table entry contains more than six braille equivalents. The detection of a prefix takes the following steps:

(1) The first six braille equivalents of the word are compared with the entries in the table of prefixes. If there is an exact match, the number 6 is stored for future use. If there is no exact match, the sixth braille equivalent is ignored, and the first five braille equivalents in the word are compared with the entries in the table of prefixes. If there is an exact match, the number 5 is stored for future use, otherwise the fifth braille equivalent is also ignored.

(2) The testing for prefixes continues until a prefix has been found or until there remain no braille equivalents to test. In the latter case, the word has no prefix.

(3) If a prefix has been found, the braille equivalents of which it is constituted are ignored, and the six braille equivalents which follow are again tested for a prefix as in items (1) and (2) above.

(4) Each time a prefix is detected the braille equivalents beyond the last detected prefix are again tested for a prefix. This testing continues until no more prefixes can be found or until there remain no more braille equivalents in the word.

(5) When as many prefixes have been detected as possible, they must be confirmed by the presence of a stem. This is effected by comparing the braille equivalents beyond the last prefix detected with the entries in the table of stems. The comparison also proceeds by the successive deletion of the final braille equivalents until a stem has been found or until there remain no more braille equivalents to test.

(6) If there remain no letters in the word after all the prefixes have been detected, the prefixes are unconfirmed and no segmentation results. If there are braille equivalents beyond the last prefix detected, but if no match can be found between any segment of these with the entries in the table of stems, the prefixes are still unconfirmed, and no segmentation results. If there are braille equivalents beyond the last prefix detected and some segment of these is an exact match with one of the entries in the table of stems, all prefixes previously detected are confirmed. Ex.:

The word river is tested successively thus obtaining the sequence

river
rive
riv
ri
r

and no match is found in the table of prefixes. Therefore, this word contains no prefixes.

The word dentist is tested successively for

dentis
denti
dent
den
de

at which point a match is found with the de entry in the table of prefixes. However successive comparisons of

ntist
ntis
nti
nt
n

with the entries in the table of stems yields no exact match. Therefore de is not confirmed as a prefix and is not enciphered separately. As a result, the en contraction will be used properly.

The word promise is tested successively for

promis
promi
prom
pro

at which point the prefix pro is detected. Thereafter the letter sequences

mise
mis

are tested and mis is found to be the next prefix. Continuing to test,

e

by itself is found to be a prefix. However, there remain no more braille equivalents for comparison with the table of stems. Therefore, none of the three prefixes which has been detected is confirmed. The word is enciphered as a whole.

The word underived is tested for the sequences

underi
under
unde
und
un

at which point the prefix un is detected. Continuing to test, the sequence

derive
deriv
deri
der
de

are considered in turn, and the prefix de is detected. Further testing in the table of prefixes fails to disclose any additional prefix. Therefore, the braille equivalents beyond the last prefix are tested in the table of stems. The sequence

rived
rive
riv

is compared, and riv is found to be an entry in the table of stems. Therefore, both of the prefixes un and de are confirmed. The un prefix is considered separately. If there is room on the braille line for this prefix and one space more, the braille equivalents for u and n are transferred to the braille line. The prefix de is considered next. If there is room for the de and for one more cell, the de is also transferred to the braille line. But if there is no room for the de and one more cell, the braille equivalent of the hyphen is adjoined to the braille line and encipherment continues on the next braille line. After the de has been adjoined to the braille line, the remainder of the word is considered. If there is no room on the braille line for the remainder of the word, the hyphen will be adjoined to the braille line and the remainder of the word will continue on the next braille line. By this means, the er contraction is avoided and this avoidance is in accordance with the rules of English Braille.

Because of the prefix-stem segmentation, a large number of words are properly enciphered by the avoidance of certain contractions and, furthermore, are properly hyphenated. Ex.:

The ea contraction is correctly avoided in word such as reassemble, pre-announced.

The ed contraction is correctly avoided in words such as reduce, educe, seductive.

The en contraction is correctly avoided in words such as renumber, denumerable, renounce.

The er contraction is correctly avoided in words such as derail, rerun, prerequisite.

The dis contraction is correctly avoided in words such as disulphide, disyllabic.

The sh contraction is correctly avoided in words such as mishandle, mishap.

The st contraction is correctly avoided in words such as mistimed, mistrial.

2.2.5.1.2 Roots

If the attempt to segment a word into one or more prefixes followed by a stem fails, a second type of segmentation is attempted. This time, the word is tested to determine if it is composed of two consecutive roots. For the purposes of this investigation, a <u>root</u> is a sequence of letters which is a word in itself, but which is a part of a larger word. The words <u>foothill</u>, <u>shorthand</u>, and <u>sawhorse</u> are examples. The analysis proceeds in descending order as described in the preceding section.

By this type of segmentation, another large class of words is enciphered with the proper avoidance of contractions. Hyphenation, if necessary, is again possible between two root words. Ex.:

The <u>ea</u> contraction is correctly avoided in words such as <u>pineapple</u>, <u>hideaway</u>.

The <u>ed</u> contraction is correctly avoided in words such as <u>kettledrum</u>, <u>ropedancer</u>.

The <u>en</u> contraction is correctly avoided in words such as <u>toenail</u>.

The <u>er</u> contraction is correctly avoided in words such as <u>storeroom</u>.

The <u>gh</u> contraction is correctly avoided in words such as <u>foghorn</u>, <u>doghouse</u>.

The <u>sh</u> contraction is correctly avoided in words such as <u>sheepshead</u>, <u>grasshopper</u>.

The <u>st</u> contraction is correctly avoided in words such as <u>Youngstown</u>.

The <u>th</u> contraction is correctly avoided in words such as <u>penthouse</u>, <u>posthole</u>.

The <u>the</u> contraction is correctly avoided in words such as <u>sweetheart</u>, <u>stouthearted</u>.

The <u>wh</u> contraction is correctly avoided in words such as <u>rawhide</u>, <u>sawhorses</u>.

2.2.5.1.3. Suffixes and Preferred Usage

No attempt is madehowever to segment a word so that a suffix, if any, may be enciphered separately. Instead, the problem is solved by storing letter combinations other than contractable combinations in such a way that the correct contractions will be used. Ex.:

The word <u>agreeable</u> contains no prefix and is not a combination of two root woods. Therefore, the word is enciphered as a whole. The presence of the letter combination <u>eable</u> in the table of part word contractions insures that the braille equivalents for this letter combination will be selected and the word correctly enciphered before the letter sequence has been recuced to <u>ea</u> and the corresponding contraction incorrectly selected.

The same technique is used to select the preferred sequence of braille equivalents when there is a choice. Ex.:

In the combination ffor as in effort, the preference is to use the braille equivalent of the f followed by the for contraction. If this letter sequence were not stored in the table of part-word contractions, the sequence would eventually reduce to ff for which there is a correct contraction and the ff contraction would be incorrect. Thus ffor is one of the entries in the table of part-word contractions. Similarly cch is an entry, assuring the use of the ch contraction preceded by the braille equivalent of the c, rather than the use of the cc contraction followed by the braille equivalent of the letter h. The storage of the ear combination will assure that the braille equivalent of the e will be followed by the ar contraction. Without this entry the ea contraction followed by the braille equivalent of the r would have been enciphered, which is incorrect.

2.2.5.2 Enciphering into Grade Two

When a word has been segmented, each segment is separately enciphered into Grade Two. When a word does not permit segmentation the entire word is enciphered into Grade Two. In either case, the encipherment proceeds in the backward direction; after each unsuccessful attempt to find a contractable combination, the last letter is deleted and the residue again tested. By this means, either a contraction or a braille equivalent of a single letter must be found. The braille equivalent is transferred to the enciphered word. The single letter or the contractable combination of letters is detached from the buffered information area and the remainder of the word segment or the word is subjected to the same procedure.

2.2.6 Economy of Storage

One further program technique requires elaboration, namely, a description of the method of storage of braille equivalents in a single location, regardless of the number of equivalents involved.

It has been previously mentioned that each location within the digital computer has a capacity of ten digits corresponding to a capacity of five braille equivalents. When a sequence of braille equivalents contains five or fewer individual equivalents, these are stored into one location in a natural way.

If, however a braille equivalent contains more than five individual equivalents, the one-location number is obtained merely by adding together the numbers in the locations where the equivalents are stored naturally. Ex.:

The word necessary is in the buffered information area. The configuration is as follows:

LOCATION 1: 52 14 11 14 61
LOCATION 2: 61 18 34 53 00

he contents of Locations 1 and 2 are added together. The 1 which is carried ver when adding the leftmost columns is discarded. The resulting configuration s

13 32 45 67 61.

o determine whether the word necessary is a contractable combination, the above rgument is eventually compared with the entries in the table of short form conractions, and the exact match is found there. From a parallel table, the short orm contraction

52 14 11

s thus found.

This technique of telescoping table entries effects not only an economy in he length of a table, but in the number of instructions required to consult the able as well. The likelihood of obtaining a meaningful combination leading to ncorrect encipherment by the use of this technique is extremely remote, and no uch occurrence has been noted in this investigation.

3 RESULTS AND CONCLUSIONS

The complete details for every phase of the procedure have not yet been formulated, so that the entire program has not been operated at once. However, large sections of the program have been operated and the results are now cited.

3.1 Encipherment into English Braille, Grade Two

In this run no attempt was made to divide the text into lines of braille. A list of 4,000 words, not constituting sentences, was punched up and submitted to the program.

(1) The section of the program required to accomplish the task occupied about 400 locations of the IBM 650 memory, which is about 20% of the available storage.

(2) 109 words were incorrectly enciphered. The errors were due mostly to an insufficiently comprehensive table of prefixes. By lengthening this table by 20 items, the errors would have been reduced from 109 to 31. The addition of 4 more items to the table of roots would have eliminated six additional errors. The remaining 25 errors require a table of exceptional words.

(3) The running time was at the rate of about 150 words per minute. For the purposes of the calculation, the word was taken to be a sequence of five braille equivalents.

3.2 Contraction-Independent Problems

A list of about 500 items requiring the letter sign or the avoidance thereof, the number sign or the avoidance thereof, and the use of transposable signs of arithmetic and transposable abbreviations were punched up and submitted to the computer. The output was continuous; no attempt was made to divide the output into lines of braille.

(1) The section of the program required to handle such problems occupied about 400 locations within the computer, including the table of cumulative information and classification numbers. This is about 20% of the available storage.

(2) All items were enciphered correctly.

(3) No attemptwas made to record the running time for such items, but the impression was gained that the running time was faster for these items than for words requiring encipherment into English Braille, Grade Two.

3.3 Format Controls

Only braille control, space control, and volume control were tested of the nine format controls described. These were tested independently of any text material; they operated properly.

3.4 General Conclusions

The method of encipherment by which the skill of a human operator in the transcription of English Braille, Grade Two, is transferred to a digital computer seems entirely feasible. It is possible to create an output which is in complete accord with the rules of English Braille, Grade Two, and which conforms to all the requirements of format needed in the final braille product.

Although the complete program has not been stored in the IBM 650, it is estimated that the number of locations required when this is done will be between 80% and 90% of the available storage. Computers more modern than the IBM 650 offer greater advantages. Many have a storage capacity which is somewhat greater than is available in the IBM 650. Many modern computers are completely alphabetic rather than alphanumeric. This means that a single letter of the alphabet can be stored in one digit position, rather than requiring two digits for its representation as is the case in the IBM 650. The more modern machines dispense with the use of an accumulator, and this feature reduces the number of program instructions required when modifying or transferring information. Furthermore, more modern machines have a variable word length storage capability rather than a six word length of ten digits as in the IBM 650. This feature still further lightens the task of transferring information from one area to another. The speeds of such machines are often considerably in excess of the speed attainable with the IBM 650. The economy of program instructions achieved because of the absence of an accumulator and because of the variable word length feature makes the factor of speed still more advantageous. All of these factors contribute to the feasibility of transferring the IBM 650 to a more modern computer.

The factor of cost could not be evaluated. Much of the cost lies in those parts of the system which are peripheral to the digital computer itself. Such items of cost include the salaries of the keypunch-operator, the proofreader, the cost of input and output, the salary of an attendant at the stereograph machine, the cost of the zinc plates and of the braille paper, etc. Some of these items, such as the salaries for the keypunch operator and proofreader are instead of the salary of a braille stereograph operator. Other items, such as the cost of input and output, are not a factor in the more usual method of encipherment.

APPENDIX TO SECTION 1.4.2.2

As computers with increasingly larger storage capacities become prevalent, many of the situations which heretofore required the attention of an editor can now be effectively and automatically handled by the computer itself.

(1) Besides the information already provided to the computer in the form of the number of cells per braille line and the number of lines per braille page, the braille transcription can automatically be divided into volumes of suitable length and of approximately equal size by providing the following additional information:

a. Number of characters on the printed line;

b. Number of lines on the printed page;

c. Number of pages in the printed text;

d. List of page numbers in the printed text on which chapters begin or on which other suitable points of division occur;

e. Optimum number of pages per braille volume.

(2) When the editor has furnished a running head and has specified where it must be placed, the running head can be enciphered into braille by the computer, and the number of braille spaces on the line which it occupies can be computed.

(3) By providing a table of page numbers in the printed text containing captions which are listable in a table of contents, the computer can automatically prepare and encipher a table of contents for each braille volume.

(4) Although figures, charts, graphs, and materials of a similar nature must still be inserted by a human operator, the amount of space occupied by such material as well as the exact position in the braille text at which it must be inserted can easily be calculated by the computer. What is required for this purpose is the storage capacity for holding the contents of two entire braille pages. Allowing 40 cells to the braille line and 25 lines to the braille page and taking for granted that storage in the more modern computers is alphameric, so that one braille character can be stored in one storage location, 2,000 storage locations are required. Since present-day computers of even intermediate size commonly have storage capacities in the neighborhood of 80,000 locations, the setting aside of 2,000 locations is not unreasonable.

(5) By utilizing the ability to store two full braille pages, the calculation of the spacerequired for footnotes, as well as their insertion into the text at the proper point can also be made fully automatic.

(6) By utilizing this same ability, a center heading can be placed either on the page which is currently being enciphered, or it can be deferred to the top of the next page, depending upon the availability of space on the current braille page, or the lack thereof, for the placement of some of the material which follows the centered heading.

(7) By storing an adequate table of the more common anglicized and foreign words and phrases, the proper use or avoidance of contractions can be assured. Such a table can be considerably shortened if words and phrases containing no contractable combinations are omitted, for in such cases, the avoidance of a contraction does not become an issue.

APPENDIX TO SECTION 1.4.2.3

With the increasing versatility of input and output equipment, and with the pronounced tendency to make modern computers alphameric, the special training which an operator must undergo to operate a keypunch in a manner which will result in correct encipherment into English Braille, Grade Two, can be considerably minimized.

(1) On the one hand, keypunches which are more modern than the IBM 024 used in this investigation are capable of producing more card codes (punch patterns) than were available with the IBM 024. In fact, by using the multiple-punch key, it is possible to form any desired punch pattern in any card column. On the other hand, the number of distinct character codes which can be recognized by a modern computer is greater than the 48 which could be used by the IBM 650. Today's standard IBM interchange code contains 64 characters, and, unlike the 650, each one can be stored in a single location by a computer which is alphameric. The increased versatility of the keypunch means that the operator must learn far fewer compound key combinations than was heretofore necessary. Format control, and the composition signs peculiar to braille, still require special implementation.

(2) By using the greater storage capacity of modern computers, most of the tasks heretofore assigned to the operator can be assumed by the computer after analysis of the configurations available as the result of the additional stored information. Among the tasks of which the operator may be relieved are the following:

a. A sequence of punctuation marks and composition signs can be arranged in the order prescribed by the rules of braille when sufficient information is stored, and the operator need have no knowledge of the required order.

b. The apostrophe can be inserted automatically before the s when the s is adjoined to a letter, number, or abbreviation to form their plural. The apostrophe can also be supplied in special words such as OKd and hm!.

c. The configuration of characters which surround the asterisk, as well as the number of asterisks can be used to furnish information as to whether the asterisk is used for making a reference, for indicating omission, or merely for ornamentation, and the appropriate action taken in any case.

d. Spacing associated with the hyphen can be ignored and the spacing rules of braille used instead. The hyphen can be ignored, inserted, replaced by other punctuation, or made to replace other punctuation, depending on the configuration available in the neighborhood of the hyphen or other punctuation, in accordance with braille requirements.

e. When enough information is stored, it is possible to detect whether the roles of the inner and outer quotation marks have been reversed and, if so, to revert to the natural order as required by the rules of braille. Quotation marks which surround single letters may be suppressed, as required by the rules of braille.

f. The accent mark which appears over the second o in words such as cooperate and coordinate can be ignored, if present, as required by the rules of braille.

g. The operator may use capitalization as with an ordinary typewriter, but the computer can be programmed to use the single or double capital sign in accordance with the rules of braille, based on the presence of sufficient information to make the decision. It should be noted, that on the keypunch, as opposed to the typewriter, only one type of letter can be produced. Accordingly, two special punches, signifying "shift key" and "shift lock," respectively, must be available to the operator in order to simulate ordinary typewriter usage for capitalization.

h. Although the operator must still decide when to indicate the use of italic type and when to avoid making such an indication, the manner of actually making the indication can be greatly simplified. For this purpose it is necessary to provide only two punches corresponding to "begin italic type" and "end italic type." With sufficient information in storage, the single and double italic signs required by the rules of braille can be supplied by the computer.

i. Roman numerals, with or without endings, can be identified, and the letter sign can be supplied or withheld in accordance with the rules of braille by the computer.

j. The transposition sign can be entirely eliminated as a special sign, and the computer can make the required analysis and effect the required transposition in the presence of enough stored information.

(3) Besides the operation of a keypunch by a human operator, information can be supplied to a computer by means of a punched paper tape used by a publisher to control the operation of a typesetting machine. In connection with this type of input, the following points should be noted:

a. No uniformity exists in the kind of tape which publishers use (paper tape from five to eight channels are in common use) or in the punch patterns used for character representation. It may therefore be necessary to have a device to convert the information from a publisher's tape into a form acceptable by the computer employed to effect the encipherment into braille.

b. Some of the characters on a publisher's tape are for the purpose of controlling the movement of the particular typesetting machine for which the tape is intended. The tape must therefore be pre-edited. Pre-editing consists in ignoring such characters when they are irrelevant, and otherwise using the information which they provide to produce correct encipherment into braille. The pre-editing operation will depend on the nature of the typesetting machine for which the tape was intended, and a different pre-editing program will be required for each kind of tape to be processed.

c. After a publisher's tape has done its work of typesetting, it is usually regarded as a waste product. Therefore, such tapes should

be readily available for braille encipherment. Furthermore, many such tapes contain material which is current. The factors of low cost, ready access, and recency of material make this form of input particularly desirable.

(4) Still another possibility for input is an optical character-recognition device. Such devices are still too restricted with respect to the kinds of characters which they can recognize, and the material scanned by such devices must usually be specially prepared so as to come within their capability, but as technological advances succeed in removing such restrictions, this method for supplying information to be enciphered into braille has obvious advantages. Pre-editing of the information supplied in this way will, of course, also be required.

APPENDIX TO SECTION 2.2.4

This appendix supplies the details for building up the enciphered word by the use of cumulative information and classification numbers.

Table A lists the cumulative information numbers and the information which is supplied by each.

Table B contains the actual method for building up the enciphered word. The first column contains the latest cumulative information number, and the second column contains the classification number resulting from the latest encipherment. The third column contains the new cumulative information number which replaces the old one on the basis of the newly acquired information. The fourth column lists the action taken to build up the enciphered word. This action is specified by a sequence of procedures, each of which is in mnemonic form.

Table C lists the meaning of each of the mnemonics in Table B. In addition, a suitable comment is furnished where appropriate.

When all the procedures have been executed, or if no action at all is taken, the cumulative information number and the classification number are again combined to form a table argument as explained in section 2.2.4. The next action to be taken is then prescribed in the corresponding table entry.

TABLE A
CUMULATIVE INFORMATION NUMBERS AND THE INFORMATION SUPPLIED BY EACH

Cum. Inf. No.	Information Supplied
00	No representations have been enciphered in the current unit of context, or previous encipherment is irrelevant.
20	The representation just enciphered is the dollar sign, section sign, or paragraph sign.
29	All previous characters are in the enciphered word area, and no further contractions are permitted in the current unit of context.
45	The accent sign, by itself or preceded by a single or double capital sign, is in the buffered information area.
51	Single letter other than i is followed by a period and, possibly, by other right punctuation marks, and these characters are assembled in the buffered information area.
55	Numeric characters followed by the colon are in the buffered information area.
56	The apostrophe has just been detected.
58	Numeric characters followed by the colon followed by more numeric characters are in the buffered information area.
61	a is the first letter in the unit of context and is in the buffered information area.
62	i is the first letter in the unit of context and is in the buffered information area.
64	o is the first letter in the unit of context and is in the buffered information area.
66	Letter other than a, i, or o is the first letter in the unit of context and is in the buffered information area.
67	The alphabetic part of the unit of context is being assembled in the buffered information area.
70	The number sign and succeeding characters are in the buffered information area, and the contraction for the ordinal ending th may follow these characters, but no other contraction.
71	The number sign and succeeding characters are in the buffered information area, and the contraction for the ordinal ending st may follow these characters, but no other contraction.

TABLE A (continued)
CUMULATIVE INFORMATION NUMBERS AND THE INFORMATION SUPPLIED BY EACH

Cum. Inf. No.	Information Supplied
72	The number sign and succeeding characters are in the buffered information area, and no contraction may follow these characters.
73	The transposition sign has just been detected.
74	Transposable abbreviation followed by numeric characters are in the enciphered word area.

TABLE B
METHOD FOR BUILDING UP THE ENCIPHERED WORD

	Cum. Inf. No.	Class. No.	New Cum. Inf. No.	Action Taken (Mnemonic)
	00	00	00	SUCPS-EODLR
	00	10	00	TOSBL-DTNUO
	00	11	00	TTSBL-DTNUO
	00	20	20	SUPSN-TEREW-EODLR
	00	21	72	TNSBI-TERBI-ETARP-TEREW-EODLR
*2	00	22	29	TEREW-EODLR
	00	30-38	00	RONIF
*1	00	40	00	TEREW-EODLR
*1	00	41	00	TERBI-TPTAR If arithmetic representation is present: OON29-ETARP-TEREW-TLSEW-AFLBI-TBIEW-RBIIC-EODLR If arithmetic representation is not present: EODLR
	00	43	72	TERBI-EODLR
	00	44	29	TEREW-EODLR
	00	45	45	TERBI-EODLR
*1	00	49	00	TEREW-EODLR
*2	00	50-55	29	TEREW-EODLR
*3	00	56	56	EODLR

*1 The presence of left punctuation, the single or double italic sign, and the single or double capital sign has been established during the SUCPS procedure and this information need not be accumulated.

*2 Provision is made for unrealistic combinations to avoid losing control of the program.

*3 The presence of the apostrophe having been established, its braille equivalent can be properly placed as soon as the next representation is known.

TABLE B (continued)
METHOD FOR BUILDING UP THE ENCIPHERED WORD

Cum. Inf. No.	Class. No.	New Cum. Inf. No.	Action Taken (Mnemonic)
00	57	00	IPOSD- SUCPS-TERBL-ECDLR
00	61	61	SUCHL-TERBI-TPTAR If arithmetic representation is present: CON29-ETARP-TEREW-TLSEW-AFLBI-TBIEW-RBIIC-ECDLR If arithmetic representation is not present: ECDLR
00	62	62	SUCHL-TERBI-TPTAR If arithmetic representation is present: CON29-ETARP-TEREW-TLSEW-AFLBI-TBIEW-RBIIC-ECDLR If arithmetic representation is not present: ECDLR
00	63	66	SUCHL-TERBI-TPTAR If arithmetic representation is present: CON29-ETARP-TEREW-TLSEW-AFLBI-TBIEW-RBIIC-ECDLR If arithmetic representation is not present: ECDLR
00	64	64	SUCHL-TERBI-TPTAR If arithmetic representation is present: CON29-ETARP-TEREW-TLSEW-AFLBI-TBIEW-RBIIC-ECDLR If arithmetic representation is not present: ECDLR
00	65-66	66	SUCHL-TERBI-TPTAR If arithmetic representation is present: CON29-ETARP-TEREW-TLSEW-AFLBI-TBIEW-RBIIC-ECDLR If arithmetic representation is not present: ECDLR
00	70	70	TNSBI-TERBI-ETARP-TEREW-ECDLR
00	71	71	TNSBI-TERBI-ETARP-TEREW-ECDLR
00	72	72	TNSBI-TERBI-ETARP-TEREW-ECDLR
00	73	00	ECDLR
20	10-11	29	none
20	20	00	none
20	21	72	TNSBI-TERBI-ECDLR

TABLE B (continued)
METHOD FOR BUILDING UP THE ENCIPHERED WORD

Cum. Inf. No.	Class. No.	New Cum. Inf. No.	Action Taken (Mnemonic)
20	22-40	29	TEREW-ECDLR
20	41	29	TLSEW-TEREW-ECDLR
20	43	72	TERBI-ECDLR
20	44-57	29	TEREW-ECDLR
20	61-66	29	TLSEW-TEREW-ECDLR
20	70-72	72	TNSBI-TERBI-ECDLR
20	73	00	none
29	10-11	00	AFLEW-TEWBL-REWIC-TOSBL-DTNUC
29	20	29	TEREW-ECDLR
29	21	72	TNSBI-TERBI-ECDLR
29	22-41	29	TEREW-ECDLR
29	43-44	00	none
29	45	29	TEREW-ECDLR
29	40-55	00	none
29	56	29	TEREW-ECDLR
29	57	00	AFLEW-TEWBL-REWIC
29	61-66	29	TEREW-ECDLR
29	70-72	72	TNSBI-TERBI-ECDLR
29	73	00	AFLEW-TEWBL-REWIC
45	10-57	29	AFLBI-TBIEW-RBIIC
45	61-66	67	AFLBI-TBIEW-RBIIC-TEREW-ECDLR
45	70-73	29	AFLBI-TBIEW-RBIIC
51	10	61	none

TABLE B (continued)
METHOD FOR BUILDING UP THE ENCIPHERED WORD

Cum. Inf. No.	Class. No.	New Cum. Inf. No.	Action Taken (Mnemonic)
51	11	61	TLSEW
51	20-49	29	AFLBI-TBIEW-RBIIC
51	50-56	51	TERBI-ECDLR
51	57	29	TLSEW-AFLBI-TBIEW-RBIIC
51	61-73	29	AFLBI-TBIEW-RBIIC
55	10-66	70	none
55	70-72	58	TERBI-ECDLR
55	73	29	AFLBI-TBIEW-RBIIC
56	10-57	29	TASEW
56	61-66	67	TASEW-IPOAS-TERBI-ECDLR
56	70-72	72	TNSBI-TASBI-TERBI-ECDLR
56	73	29	TASEW
58	10-53	70	none
58	54	70	SUCHN If hyphen is followed by numeric character: TERBI-TNSBI-ECDLR If hyphen is not followed by numeric character: AFLBI-TBIEW-RBIIC-CCN29
58	55-66	70	none
58	70-72	58	TERBI-ECDLR
58	73	70	none
61	10-11	29	AFLBI-TBIEW-RBIIC
61	20-38	00	AFLBI-TBIEW-RBIIC
61	40-49	67	TERBI-ECDLR
61	50	00	TLSEW-AFLBI-TBIEW-RBIIC

TABLE B (continued)
METHOD FOR BUILDING UP THE ENCIPHERED WORD

Cum. Inf. No.	Class. No.	New Cum. Inf. No.	Action Taken (Mnemonic)
61	51	51	TERBI-EODLR
61	52	67	TERBI-EODLR
61	53	00	TLSEW-AFLBI-TBIEW-RBIIO
61	54	67	TERBI-IPOTH-OHPLI If hyphen-plus-letter indicator is on: AFLBI-TBIEW-RBIIO If hyphen-plus-letter indicator is off: TLSEW-AFLBI-TBIEW-RBIIO
61	55	00	TLSEW-AFLBI-TBIEW-RBIIO
61	56	67	SUOLS If s is present: TLSEW-TERBI-EODLR If s is not present: TERBI-EODLR
61	57	29	TLSEW-AFLBI-TBIEW-RBIIO
61	61-66	67	TERBI-EODLR
61	70-72	29	AFLBI-TBIEW-RBIIO
61	73	29	AFLBI-TBIEW-RBIIO
62	10-11	61	CPSCS If capital sign is present: none If capital sign is not present: TLSEW
62	20-49	61	none
62	50-51	00	CPSCS If capital sign is present: AFLBI-TBIEW-RBIIO If capital sign is not present: TLSEW-AFLBI-TBIEW-RBIIO
62	52	61	none

TABLE B (continued)
METHOD FOR BUILDING UP THE ENCIPHERED WORD

Cum. Inf. No.	Class. No.	New Cum. Inf. No.	Action Taken (Mnemonic)
62	53	00	OPSOS If capital sign is present: AFLBI-TBIEW-RBIIO If capital sign is not present: TLSEW-AFLBI-TBIEW-RBIIO
62	54	61	none
62	55	00	OPSOS If capital sign is present: AFLBI-TBIEW-RBIIO If capital sign is not present: TLSEW-AFLBI-TBIEW-RBIIO
62	56	67	OPSOS If capital sign is present: TERBI-ECDLR If capital sign is not present: TLSEW-TERBI-ECDLR
62	57	29	AFLBI-TBIEW-RBIIO
62	61-73	61	none
64	10-11	62	none
64	20-49	61	none
64	50-73	61	none
66	10-11	61	TLSEW
66	20-49	61	none
66	50-73	61	none
67	10-11	00	AFLBI-EBIGT-AFLEW-TEWBL-REWIC-TOSBL-DTNUC
67	20-44	29	AFLBI-TBIEW-RBIIO
67	45	67	TERBI-ECDLR
67	49-55	29	AFLBI-TBIEW-RBIIO
67	56	67	TERBI-ECDLR

TABLE B (continued)
METHOD FOR BUILDING UP THE ENCIPHERED WORD

Cum. Inf. No.	Class. No.	New Cum. Inf. No.	Action Taken (Mnemonic)
67	57	29	AFLBI-EBIGT
67	61-66	67	TERBI-ECDLR
67	70-73	29	AFLBI-EBIGT
70	10-11	29	AFLBI-TBIEW-RBIIO
70	20	00	AFLBI-TBIEW-RBIIO
70	21	72	TERBI-ECDLR
70	22-51	29	AFLBI-TBIEW-RBIIO
70	52	72	TERBI-ECDLR
70	53	70	SUONS-TBLSA If both conditions are affirmative: TERBI-ECDLR If first condition is affirmative and second is negative: AFLBI-TBIEW-RBIIO-TEREW-AFLEW-TEWBL-REWIO-THTBL-ECDLR If first condition is negative: AFLBI-TBIEW-RBIIO-OON29
70	54	72	TERBI-ECDLR
70	55	55	TERBI-ECDLR
70	56	29	AFLBI-TBIEW-RBIIO
70	57	29	AFLBI-TBIEW-RBIIO
70	61-63	29	AFLBI-TBIEW-RBIIO-TLSEW
70	64-65	29	AFLBI-TBIEW-RBIIO
70	66	29	AFLBI-TBIEW-RBIIO-SUOTH If th: TTHEW-ECDLR-ECDLR If not th: none
70	70	70	TERBI-ECDLR
70	71	71	TERBI-ECDLR

TABLE B (continued)
METHOD FOR BUILDING UP THE ENCIPHERED WORD

Cum. Inf. No.	Class. No.	New Cum. Inf. No.	Action Taken (Mnemonic)
70	72	72	TERBI-ECDLR
70	73	73	ECDLR
71	10-64	70	none
71	65	29	AFLBI-TBIEW-RBIIO-TUOST If st: TSTEW-ECDLR-ECDLR If not st: none
71	66-73	70	none
72	10-65	70	none
72	66	29	AFLBI-TBIEW-RBIIO
72	70-73	70	none
73	10-50	70	none
73	51	74	AFLBI-TBIEW-RBIIO-ECDLR
73	52	73	TEREW-ECDLR
73	53-57	70	none
73	61	73	TEREW-ECDLR
73	62	73	SUOIN If in: TINEW-ECDLR-ECDLR If not in: TEREW-ECDLR
73	63-66	73	TEREW-ECDLR
73	70-73	70	none
74	10	29	none
74	11	29	TPSEW-AFLBI-TBIEW-RBIIO
74	20-49	29	TPSEW

TABLE B (continued)
METHOD FOR BUILDING UP THE ENCIPHERED WORD

Cum. Inf. No.	Class. No.	New Cum. Inf. No.	Action Taken (Mnemonic)
74	50-56	74	TERBI-EODLR
74	57-73	29	TPSEW

TABLE C
GLOSSARY OF MNEMONICS AND COMMENTS

AFLBI Adjust the final location of the buffered information area.

Since characters are adjoined on the right, and previous information must be moved leftward to accommodate the new character, the high-order position in each location of the buffered information area is the last to acquire information. Therefore, the last location reserved for this area must be left-adjusted.

AFLEW Adjust the final location of the enciphered word area.

(see comment under AFLBI).

CCN29 Change the cumulative information number to 29.

CHPLI Check the hyphen-plus-letter indicator.

If this indicator is in a nonzero condition, the letters which precede and follow the hyphen are identical. If the indicator is in the reset condition, either the character between the letters is not the hyphen or the two letters on either side of this character are distinct.

CPSCS Check preliminary symbols for capital sign.

This information is available as the result of the SUCPS procedure.

DTNUC Develop the next unit of context.

As part of this procedure, the location which holds the classification number is reset. If a transposable arithmetic representation is enciphered during the development of the unit of context, it is stored in a special location off line from the unit of context.

EBIGT Encipher the buffered information into Grade Two.

The encipherment into Grade Two is in accordance with the principles of section 2.2.5 and its various subsections. As a result of this procedure, the buffered information area is automatically reset.

ECDLR Encipher, classify, and detach the leading representation.

Encipherment consists of finding the braille equivalent of the representation and placing it in LHBER (location holding the braille equivalent of the representation). An exception occurs when one of the format controls is "enciphered"; in that case, an instruction by which to begin the execution of the format requirement is placed into LHBER instead. Classification consists of finding the classification number corresponding to a representation and placing it into the location holding the classification number. Detachment consists of removing the representation which has been enciphered from the unit of context, and moving the remaining characters leftward to fill the space vacated by the detached character.

TABLE C (continued)
GLOSSARY OF MNEMONICS AND COMMENTS

ETARP Encipher transposable arithmetic representation if present.

If no transposable arithmetic representation is present, LHBER (location holding the braille equivalent of the representation) is reset.

IPOAS Indicate the presence of the apostrophe symbol.

By the use of such an indication, it is possible to avoid the com contraction if this combination follows the apostrophe. The indicator which signifies the presence of the apostrophe is reset by the SUCPS procedure if any left punctuation marks are present.

IPOSD Indicate the presence of the short dash.

By the use of this indication it is possible to avoid the com contraction if this combination follows the short dash. The indicator which signifies the presence of the short dash is reset by the SUCPS procedure if any left punctuation marks are present.

IPOTH Indicate the presence of the hyphen.

By the use of this indication, it is possible to avoid the com contraction if this combination follows the hyphen. The indicator which signifies the presence of the hyphen is reset by the SUCPS procedure if any left punctuation marks are present.

RBIIC Reset the buffered information area to its initial condition.

All the locations reserved for the buffered information area are reset.

RCNIF Reset the classification number and implement the format.

Implementation of the format control is initiated by the instruction in LHBER (see ECDLR).

REWIC Reset the enciphered word area to its initial condition.

All the locations of the enciphered word area are reset.

SUCHL Scan unit of context for hyphen and letter.

If the leading character in the unit of context is the hyphen, and the character which follows is the same as the letter which precedes the hyphen, the hyphen-plus-letter indicator is made nonzero. If either of these conditions is unrealized, the hyphen-plus-letter indicator is reset.

SUCHN Scan the unit of context for hyphen followed by numeric character.

SUCIN Scan the unit of context for the in contraction.

TABLE C (continued)
GLOSSARY OF MNEMONICS AND COMMENTS

SUCLS Scan the unit of context for the letter s.

SUCNS Scan the unit of context for a numeric symbol.

This procedure establishes the presence or absence of a numeric character following the comma.

SUCPS Scan the unit of context for preliminary symbols.

By <u>preliminary symbols</u> is meant one or more left punctuation marks (left parenthesis, left bracket, left outer quote, or left inner quote), the single or double italic sign, or the single or double capital sign. The following numeric designations are used to specify the various possibilities:

00: No left punctuation, no italic sign, and no capital sign.
01: Single or double capital sign only.
02: Single or double italic sign only.
03: Single or double italic sign followed by single or double capital sign, but no left punctuation.
04: One or more left punctuation marks, but no italic or capital signs.
05: One or more left punctuation marks followed by the single or double capital sign.
06: One or more left punctuation marks followed by the single or double italic sign.
07: One or more left punctuation marks, followed by the single or double italic sign, followed by the single or double capital sign.

The indicators which signify the presence of a hyphen, apostrophe, or short dash are reset by this procedure if any left punctuation marks are present.

SUCST Scan the unit of context for the st combination.

This ordinal ending contraction may be used only after the digit 1.

SUCTH Scan the unit of context for the th combination.

This ordinal ending contraction may be used only after a digit other than 1, 2, or 3.

SUPSN Supply the uncontracted paragraph sign if necessary.

The ar contraction which is part of the paragraph sign must not be used if braille control calls for encipherment into Grade One.

TASBI Transfer the apostrophe symbol to the buffered information area.

TASEW Transfer the apostrophe symbol to the enciphered word area.

TBIEW Transfer the buffered information to the enciphered word area.

TABLE C (continued)
GLOSSARY OF MNEMONICS AND COMMENTS

TBLSA Test braille line for sufficient accommodation.

Accommodation on the braille line is established to be sufficient if there remain enough cells to accommodate all the information in the enciphered word area, plus all the information in the buffered information area, plus all the characters in the unit of context up to and including the next comma or up to but excluding the next space, plus one additional cell. The purpose of this procedure is to permit a hyphen to be placed after the comma on the braille line if it is necessary to divide a number between braille lines.

TERBI Transfer the enciphered representation to the buffered information area.

As part of this procedure, LHBER (location holding the braille equivalent of the representation) is reset. If LHBER is already reset, no transfer occurs.

TERBL Transfer the enciphered representation to the braille line area.

(See TERBI).

TEREW Transfer the enciphered representation to the enciphered word area.

(See TERBI).

TEWBL Transfer the enciphered word to the braille line area.

THTBL Transfer the hyphen to the braille line area.

TINEW Transfer the *in* contraction to the enciphered word area.

The transfer is made if braille control permits; otherwise, each letter is transferred individually.

TLSEW Transfer the letter sign to the enciphered word area.

TNSBI Transfer the number sign to the buffered information area.

The number sign must precede a sequence of numeric characters, or the decimal or the apostrophe associated with a sequence of numeric characters.

TOSBL Transfer one space to the braille line area.

If a space cannot be accommodated on the current braille line, no further attempt is made to transfer it to the next available braille line.

TPSEW Transfer the period symbol to the enciphered word area.

TPTAR Test for the presence of a transposable arithmetic representation.

TABLE C (continued)
GLOSSARY OF MNEMONICS AND COMMENTS

TSTEW Transfer the st contraction to the enciphered word area.

The transfer is made if braille control permits; otherwise, the letters are transferred individually.

TTHEW Transfer the th contraction to the enciphered word area.

The transfer is made if braille control permits; otherwise the letters are transferred individually.

TTSBL Transfer two spaces to the braille line area.

(See TOSBL).

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AUTOBIOGRAPHICAL STATEMENT

Abraham Nemeth was born and educated in New York City. He received the B.A. degree from Brooklyn College in 1940, and the M.A. degree from Columbia University in 1942. He began his graduate training in mathematics at Columbia University in 1951 and transferred his work to Wayne State University after coming to Detroit in 1955. He has held teaching positions in mathematics at Manhattan College, New York City, (1953), at Manhattanville College, Purchase, New York (1954), and at the University of Detroit with which he has been associated since 1955 and where he now holds the rank of Assistant Professor.

Mr. Nemeth's interest in braille comes from his experience of having been educated as a blind person from childhood. In 1952 his Nemeth Code of Braille Mathematical Notation was published by the American Printing House for the Blind, Louisville, Kentucky. This work was revised in 1956. An enlarged version of this work is about to be published, and this Code has been adopted by the professional associations concerned with such matters as the standard Code for the writing of mathematics in braille in the United States. All mathematical works published in braille in this country since 1955 have been in accordance with this Code. In 1954, A Dictionary of Braille Musical Symbols, compiled by Mr. Nemeth, was also published by the American Printing House for the Blind.

Mr. Nemeth is a member of the Mathematical Association of America. In March, 1956, he presented a paper before the Michigan Section of that organization, entitled "A One-Page Fifteen-Place Table of Logarithms," a brief report of which appeared in the American Mathematical Monthly, Vol. 63, No. 7 (August-September, 1956), p. 519.

In 1959, Mr. Nemeth presented a paper before the Michigan Section of the Council for Exceptional Children, entitled "Teaching Meaningful Mathematics to Blind and Partially Sighted Children." A reprint of this talk appeared in The New Outlook for the Blind, November, 1959, published by the American Foundation for the Blind, New York City.

In 1960, the United Foundation selected Mr. Nemeth to narrate the film for their 12th annual Torch Drive, entitled "Push Back the Shadows." He also appeared as the principal in two radio programs and one television program, each of which was an award-winning documentary. These were: "A Noble Challenge," broadcast on WXYZ radio in January and February, 1959, "An Ordinary Life," broadcast on WJR radio in March, 1963, and "The Light Within," telecast on Channel 7 in December, 1963.

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